guide book to field trips

EASTERN SECTION

NATIONAL ASSOCIATION OF GEOLOGY TEACHERS

ANNUAL MEETING

Skidmore College
April 30 - May 1, 1976

Guidebook to Field Trips

Annual Meeting

EASTERN SECTION

NATIONAL ASSOCIATION OF GEOLOGY TEACHERS

at

Skidmore College
Saratoga Springs, New York

April 30 - May 1, 1976

Edited

by

Kenneth G. Johnson & John J. Thomas

CONTENTS

INTRODUCTION

It is difficult to visualize a region of greater geologic diversity than east-central New York. Those of us who teach here are fortunate. To the north are the ancient metamorphic and igneous rocks of the Adirondacks. To the east are the complexly folded and faulted lower Paleozoic rocks of the Taconics. To the south and west are essentially undisturbed lower and middle Paleozoic rocks that are unrivaled for the overall excellence of the fossils which they contain. The frosting on the cake, or the bane of our existence depending on whether one favors sediments or their lithified equivalents, is the well developed continuum of Pleistocene features present in east-central New York. These range from purely glacial, through glacio-fluvial and glacio-lacustrine, to aeolian in origin.

In arranging the field trips for this meeting, we have attempted to provide a good sampling of this geologic diversity. Like most such attempts, we have succeeded only to an extent; but it is hoped that you will be able to find within one or another of these excursions perceptions that will be useful in your function as a teacher of geology.

As Joe Waring indicated in his remarks at the NAGT luncheon in Philadelphia a few weeks ago, teaching is indeed a noble profession. Field meetings such as these are perhaps one of the more effective ways that we have of communicating to one another our commitment to sound and effective education in the geological sciences.

KGJ
JJT

Geology of the Southeastern Adirondacks

by

James McLelland
Colgate University

Introduction

The southeastern Adirondacks are herein defined as the topographic highlands (overwhelmingly Precambrian) that lie within a compartment whose corners are situated at: Speculator, Gloversville, Saratoga Springs, and Glens Falls (see fig. 2). The southeastern Adirondacks are part of a regional geologic framework that underlies the map area shown in fig. 1. The lithology and structure of this region is shown in figs. 2 and 3. The purpose of this trip is to show as many examples of this area's representative lithology and structure as time permits.

Previous Work

Early mapping within the southeastern Adirondacks was done by William Miller (1911, 1916, 1920, 1921), Cushing and Ruedemann (1914), Bartholome (1956), Thompson (1959), and Hills (1965). Hall (1965) and his students prepared detailed geologic maps along the east flank of the Palmerton Range. In the mid-1960's McLelland (1969) began mapping with the Canada Lake area immediately west of Sacandaga Reservoir. This work was pushed eastward and northward in the early 1970's (McLelland, 1974). The contiguous geology to the northwest of the southeastern Adirondacks represents the cumulative work of Cannon (1937), Nelson (1968), de Waard (1965), Lettney (1968), and McLelland (1975, 1976). In addition to these contributors, a great deal of the area was reconnaissanced by Y. Isachsen for the 1961 edition of the N.Y. State Geological Map.

Regional Structural Geology

(A) General Description

Three definite phases of regional folding have been recognized in the southern Adirondacks. A fourth phase of folding appears related to the anorthosite massifs. This can be seen in the vicinity of the Oregon Dome where earlier fold axes swing around the core of the dome. All of these fold sets have large dimensions with the two earliest being of unusually great extent.

The earliest fold event is isoclinal and, overall, recumbent. It is referred to as F_1 and is best represented by the Canada Lake Nappe (fig. 3). F_1 folding is also represented by the Little Moose Mt. Syncline and the Wakeley Mt. Nappe. All F_1 folds have approximately E-W axial traces and plunges within 25° of the horizontal. The style of folding is quasi-flexural with relatively competent beds such as quartzites displaying a tendency towards parallel folding.

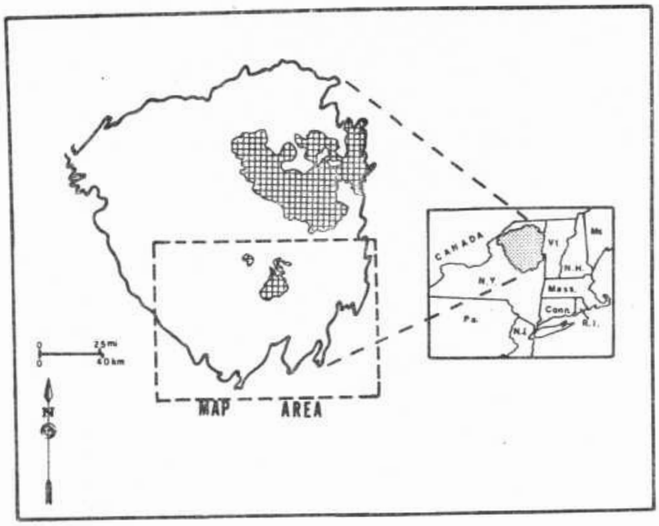


Figure 1 - Location map of the southern Adirondacks. Map area of figs. 2 and 3 indicated by dashed enclosure.

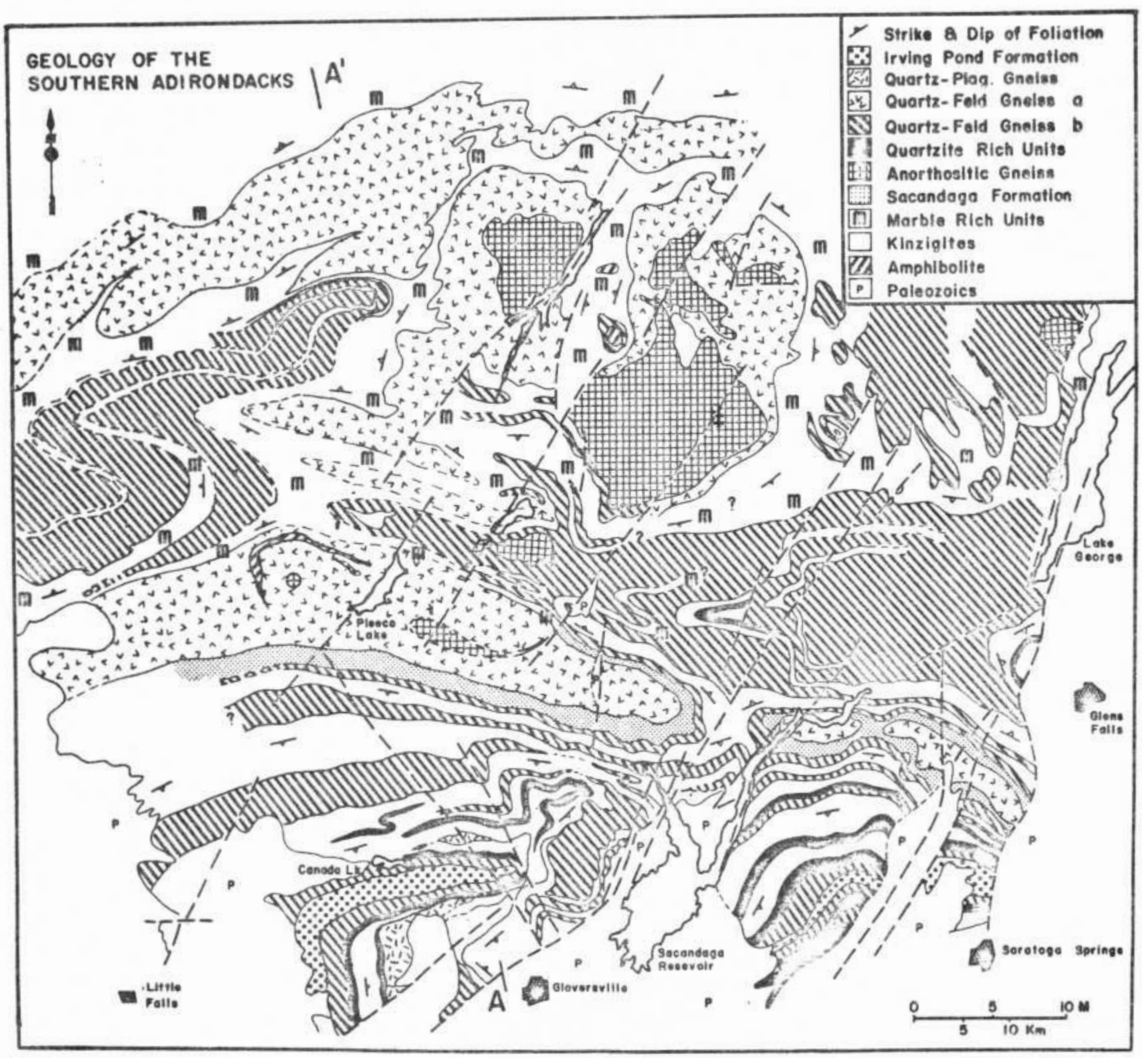


Figure 2 - Geologic map of the southern Adirondacks.

Near the hinge lines of the F_1 folds, a strong mineral lineation is developed parallel to the fold axis. In places this results in rodding and pencil gneisses. In addition, an axial plane foliation is represented by flattened mineral grains (quartz being the easiest to see) that transect compositional layering. It is difficult to assign a relative age to foliation of this sort unless it is exposed in close proximity to F_1 minor folds.

The F_2 folds of the southern Adirondacks are approximately coaxial with the F_1's. Their axial planes tend to be upright and axial plunges are within 25° of the horizontal. The best examples of the F_2 folding (fig. 3) are the Piseco Anticline, the Glens Falls Syncline, and the Gloversville Syncline. The first two exceed 100 km along their axial traces and disappear below Paleozoic cover on either margin of the Adirondacks. The Gloversville Syncline is probably of similar dimensions but occurs in an areally limited block of Precambrian.

Although the F_2 folds are relatively open as compared to the isoclinal F_1's they can hardly be called gentle flexures. Along portions of its outcrop length, the north limb of the Piseco Anticline is associated with near vertical dips while the southern limb dips south at 40°-50°. In most places the fold amplitude is of the order of several kilometers. Clearly these folds are major structures that manifest substantial orogeny.

The F_2 mineral lineation is well developed along hinge lines and is particularly marked along the crest of the Piseco Anticline where pencil gneisses are abundantly present. F_2 axial plane foliation is widely developed and is represented by flattened mineral grains or biotite. The foliation usually dips at a steep angle and transects compositional banding as well as F_1 foliation. The minor folds of the F_2 set are usually open but sometimes approach isoclinal closures. Evidently it is dangerous to assign a minor fold to F_1 or F_2 on the basis of fold form only.

The Piseco Anticline and Glens Falls Syncline are in general slightly overturned to the north with axial plane dips of the order of 70°-80° S. The Goversville Syncline, on the other hand, is overturned to the south and its axial plane dips approximately 45° north. The origin of this fanning is not presently understood and represents a major research problem.

The F_3 folds of the region trend NNE at about 90° to the F_1 and F_2 axes. This, combined with the already folded nature of the terrain, has resulted in variable plunges of the F_3 fold axes.

F_3 folds are best developed near the eastern margin of the region (fig. 3), but a very large member of the set appears to be responsible for the Snowy Mt. Dome which is located to the west (fig. 3). This F_3 anticline divides the southern Adirondacks into a western area in which lineations plunge west and an eastern area in which lineations plunge east. The Oregon Dome may also be due to an F_3 fold. Figure is suggestive of this. A more firm conclusion must away further field studies.

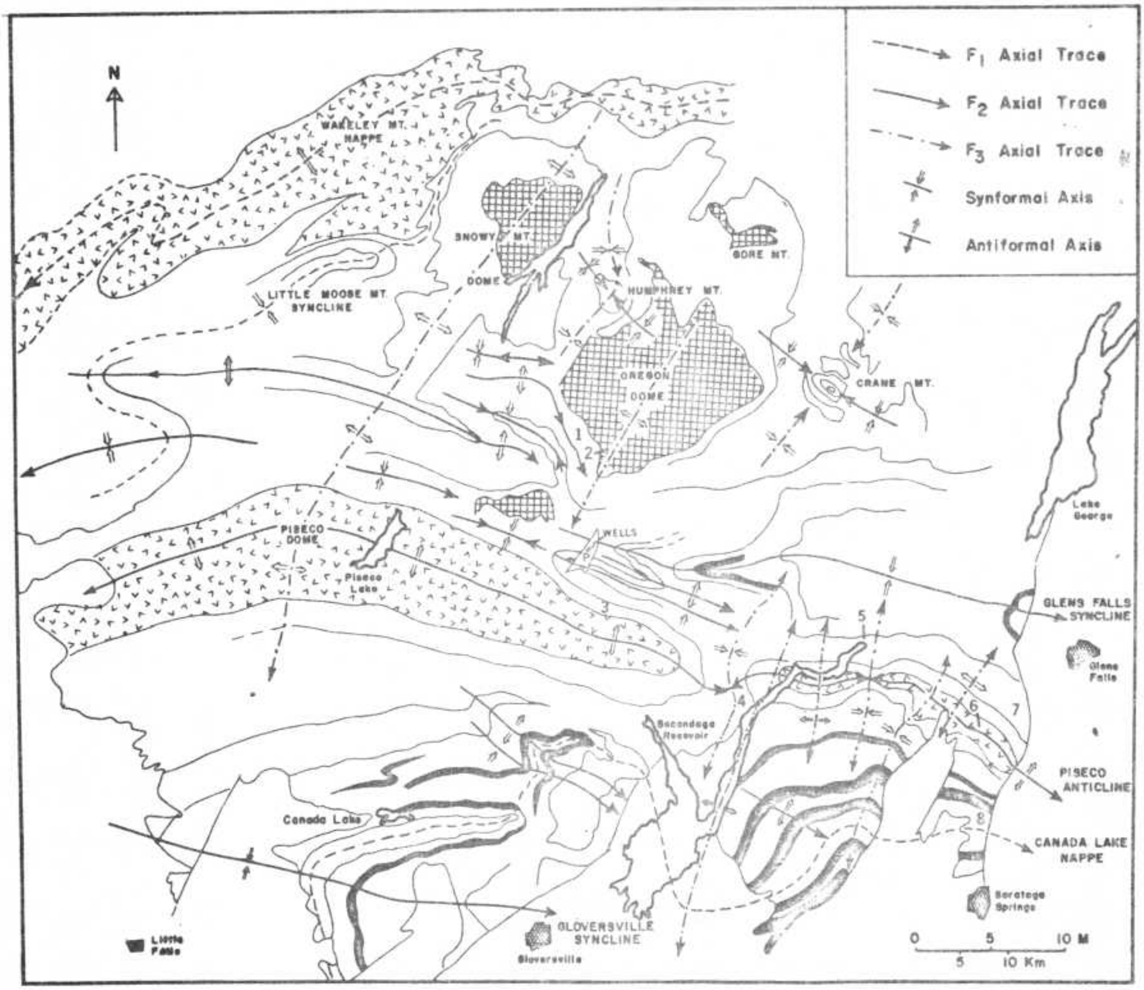


Figure 3 - Structural geology of the southern Adirondacks. Numbers 1-8 refer to stops described in Road Log.

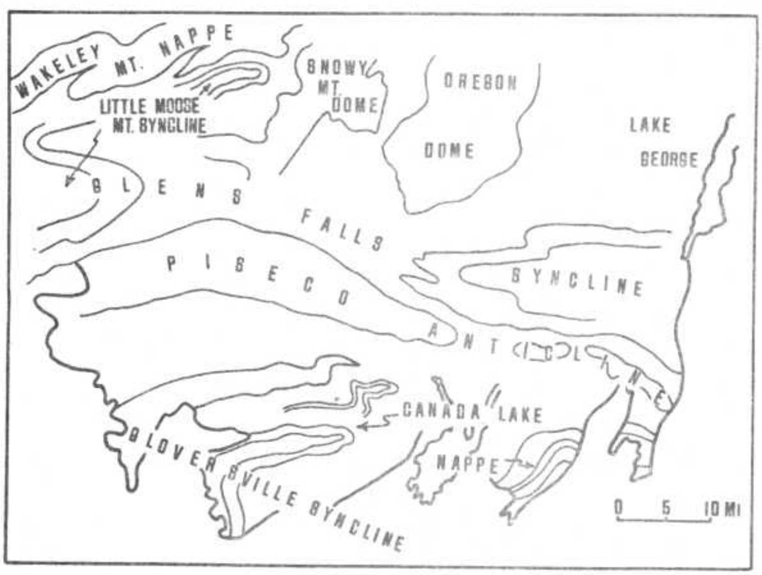


Figure 4 - Principal structural elements of the southern Adirondacks.

While large, the F_3 folds are generally of lesser dimensions than the F_1 and F_2 sets. Relatedly, F_3 mineral lineations and axial plane foliation are not developed on the regional scale associated with the first two. Mineral lineation is almost exclusively restricted to hinge line areas of F_3 folds and axial plane foliation is rarely well developed. The axial planes of the F_3 folds are upright, and their wavelength is relatively broad.

In the vicinity of the Oregon Dome, F_2 folds are seen to sweep around the anorthosite-charnockite core rocks. This pattern is similar to that exhibited by foliations enveloping the Marcy Massif to the north. There are several possible explanations for this pattern. Among these are the follwoing: (1) Crustal blocks dominated by anorthosite acted as relatively rigid buttresses during F_2 folding; (2) Anorthosite intrusion post-dated F_2 folding and shouldered aside F_2 fold axes; (3) Anorthosites are exposed in the cores of doubly plunging, or domical, F_3 folds; (4) Due to their relatively low density, anorthosites continued to rise as solid diapirs after the completion of intrusion and folding.

Evidence strongly suggests that the anorthosites were intruded prior to F_1 folding. Hence alternative (2) is considered to be unlikely. Alternative (3) appears to be unlikely on a regional scale, particularly for the Marcy Massif. Of the remaining two alternatives, (4) is preferred, but as suggested earlier, (3) may prove to be correct locally.

(B) Regional Interrelationships and Synthesis

Inspection of figs. 2 and 3 demonstrate the manner in which fold set intersection results in interference patterns. The most obvious example of this interference are found along the Piseco Anticline where intersecting F_2 and F_3 axes have resulted in a series of structural culminations and depressions. These are most clearly developed in the eastern portion of the Piseco Anticline. However, the well known Piseco Dome itself appears to be a culmination resulting from the intersection of the Piseco Anticline, (F_2), and the Snowy Mt. Anticline, (F_3).

Another excellent example of F_2 and F_3 interference is located at Crane Mt. where intersecting synclines have resulted in a structural basin. This was pointed out long ago by Yngvar Isachsen (pers. comm.) who has done much detailed work on Crane Mt. Farther to the west Humphrey Mt. may represent a similar structural basin (fig. 3).

Interference between F_1 and F_2 folds explains the "bent index finger" outcrop pattern of the Canada Lake Nappe to the northwest of Gloversville. This is depicted in fig. 8. This axial plane folding results in the sinuous path followed by the axial trace of the Canada Lake Nappe as it passes eastward. A continued eastern plunge of the nappe axis results in the nosing out of successive stratigraphic units. Upon crossing Sacandaga Reservoir the Canada Lake Nappe core rocks are brought back to the surface due to the intersection of the nappe by a large F_3 anticline (fig. 9). Although the intersection itself lies beneath Paleozoic cover, its affect is readily discernible in the presence of the Irving Pond Fm. within the section lying immediately east of Sacandaga Reservoir (fig. 2).

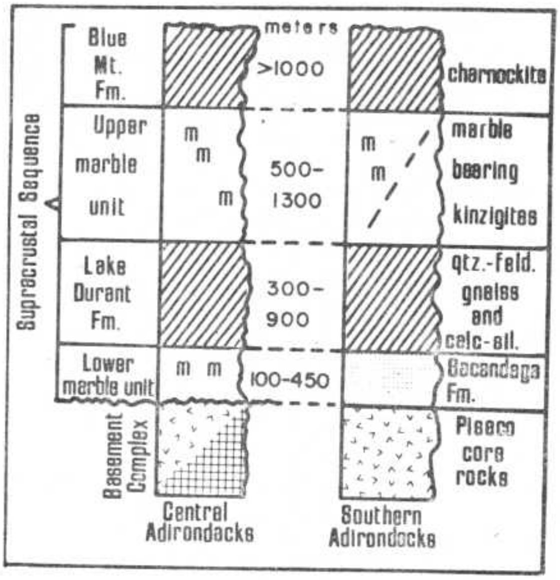


Figure 5 - Stratigraphic columns and correlation of units between the central Adirondacks (de Waard) and the southern Adirondacks (McLelland).

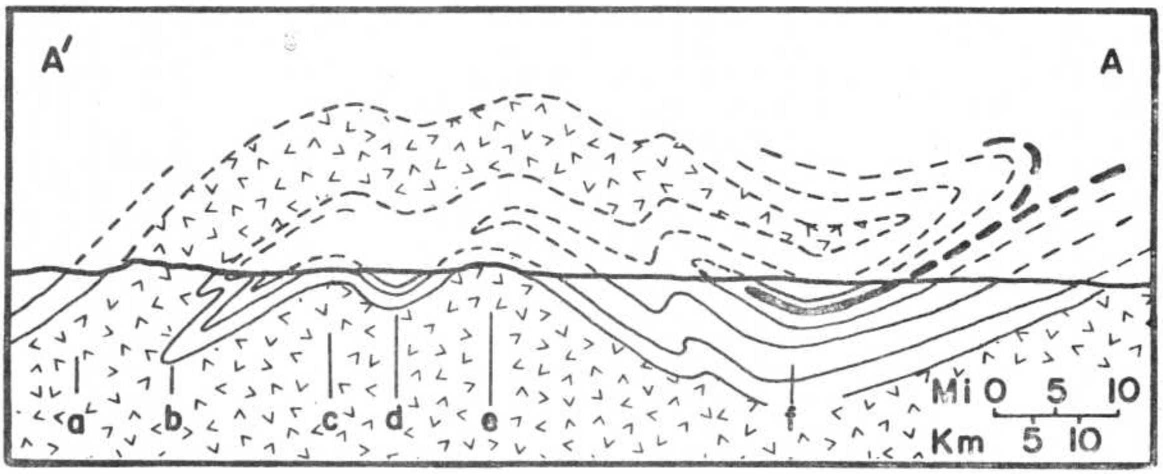


Figure 6 - Schematic cross section of the southern Adirondacks along A-A' of fig. 2. Principal folds: a) Wakeley Mt. Nappe; b) Little Moose Mt. Syncline; c) Spruce Lake Anticline; d) Glens Falls Syncline; e) Piseco Anticline; f) Canada Lake Nappe and Gloversville Syncline. Irving Pond Fm. shown in black; quartzo-feldspathic gneiss "a" is patterned (thickness unknown).

The intersection of F_1 and F_2 is of primary importance in the area. Detailed mapping of stratigraphy has demonstrated that the Canada Lake Nappe and the Little Moose Mt. Syncline are different parts of one and the same fold. The geometry of the situation is shown in figs. 6 and 7. Here it is seen that alternating F_2 synclines and anticlines cause the stratigraphy in the lower limb of the Canada Lake Nappe to be repeated for several tens of miles until the nose of the Little Moose Mt. Syncline is reached. It is not until this point that the axial plane of the Canada Lake Nappe intersects the topographic surface once more. Thus the axial trace of the Little Moose Mt. Syncline is the same as that of the Canada Lake Nappe but is located in a different stratigraphic unit. If the folds involved had perfectly horizontal axial plunges, the Canada Lake and Little Moose Mountain axial traces would never meet. However, the axes do plunge, and the two hinge lines must join to form a single, continuous axial trace. Since this junction has not been recognized within the southern Adirondacks, it is presumed to be hidden beneath Paleozoic cover to the west and to the east. Figure 7 schematically depicts the model. The speculative trends are intended to provide a topological picture only and actual points of axial trace closure are totally unknown.

Lithology and Stratigraphy

The dominant lithology of the southern Adirondacks is quartzo-feldspathic gneiss. Generally these rocks contain 15%-30% quartz and 60%-70% feldspar (largely mesoperthite). Hornblende, biotite, and garnet are common mafics. Where orthopyroxene occurs the rocks may properly be called charnockites, otherwise they are hornblende and/or biotite quartzo-feldspathic gneisses. In some instances these rocks are equigranular and in others they are markedly inequigranular displaying K-feldspar megacrysts as long as 4 inches. These variations in lithology may, in theory, be mapped. However, most quartzo-feldspathic units in the area display the entire range of textural and lithologic variations referred to above. Gradation along strike results in one or the other type being locally dominant. Rather than attempt to subdivide these units at this stage, the decision has been made to map them as stratigraphically distinct quartzo-feldspathic bands. Subdivision can more easily be done after the regional structural framework has been established.

Figure 2 shows two types of quartzo-feldspathic gneiss (types a and b). This distinction is not based upon lithologic differences but upon stratigraphic position. Quartzo-feldspathic gneisses of the "a" type are stratigraphically located so as to be candidates for de Waard and Walton's (1963) basement complex. Quartzo-feldspathic gneisses of the "b" type would be candidates for members of de Waard and Walton's supracrustal sequence. The basement-supracrustal concept will be dealt with on pp.

Implicit in figs 2 and 3, and as shown explicitly, in fig. 10, quartzo-feldspathic gneisses "a" are located at the geometeric base of the stratigraphic section. De Waard (1962) demonstrated that in the Little Moose Syncline this geometric base corresponded to a stratigraphic base as well. This conclusion rested upon determing the relative age of the rocks from the map orientation of a laccolith. Regional correlation of the stratigraphy has permitted this age determination to be extended throughout the southern Adirondacks. This correlation is discussed below.

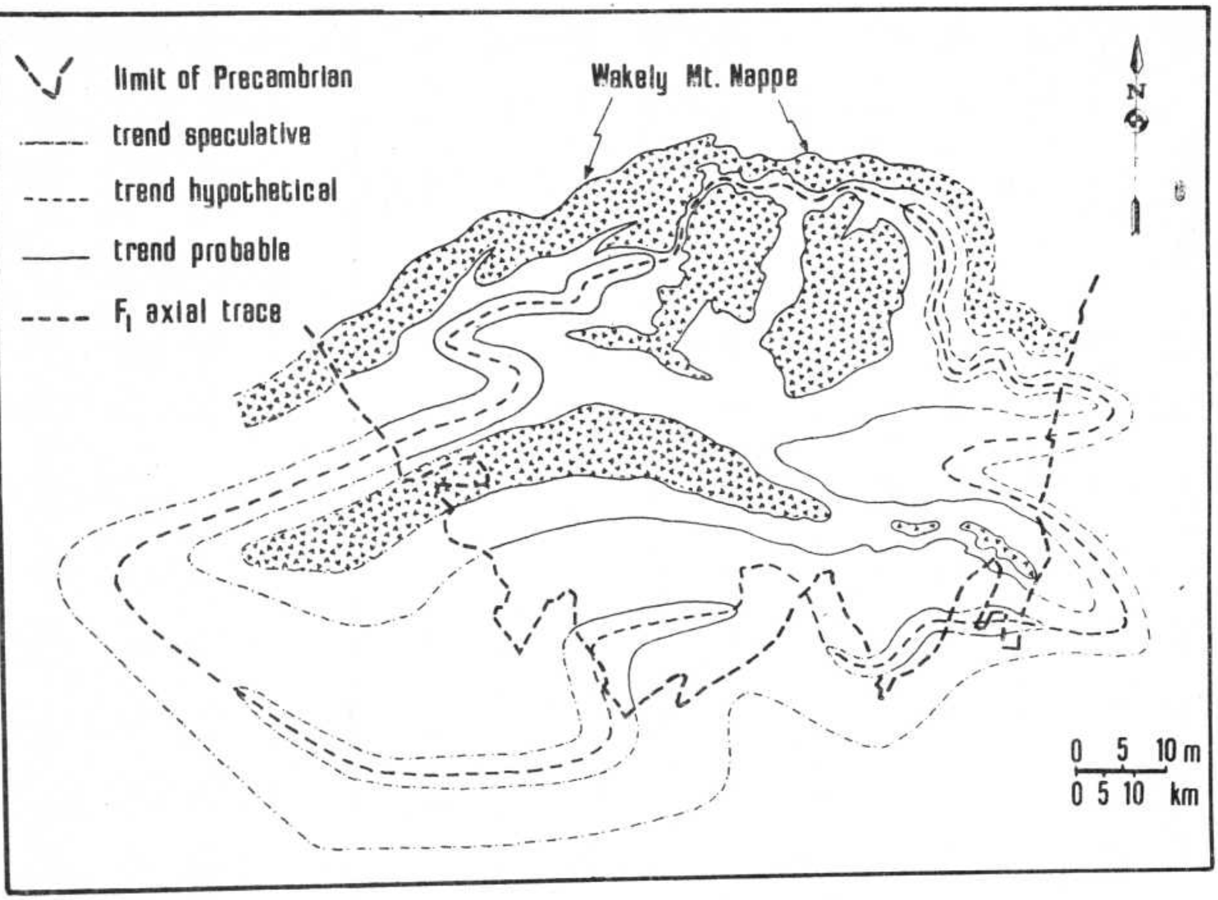
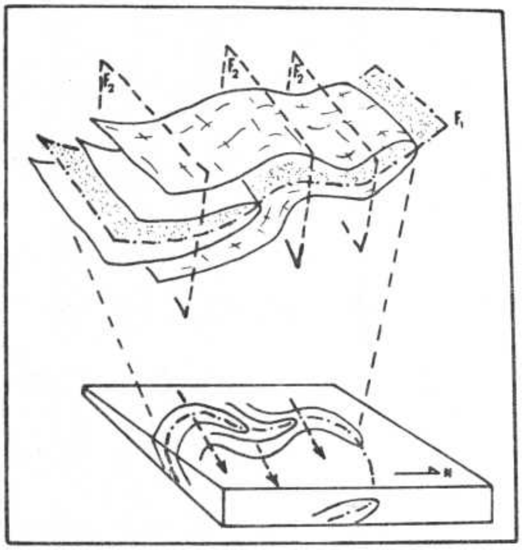


Figure 7 - Schematic representation of the topology of the F_1 axial trace of the Little Moose Mt.-Canada Lake Nappe in the southern Adirondacks. The patterned areas are major exposures of quartzo-feldspathic gneiss "a". Axial trace of the Wakeley Mt. Nappe not shown.



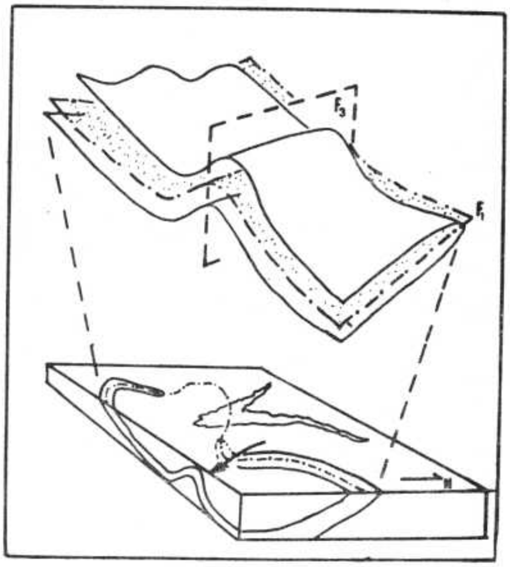


Figure 8 - Cartoon demonstrating how F_1-F_2 interference leads to the "bent-index-finger" outcrop pattern of the Canada Lake Nappe in the area west of Sacandaga Reservoir.

Figure 9 - Cartoon demonstrating how F_1-F_3 interference results in the remergence of the Canada Lake Nappe core rocks to the east of Sacandaga Reservoir (V-shaped body in figure).

Quartzo-feldspathic gneisses "a" constitute the core rocks of the Piseco Anticline. Within the southeastern Adirondacks, these are directly overlain by a very distinctive set of paragneisses referred to as the Sacandaga Fm (McLelland, 1974). This formation, named for its magnificent exposures along the north shore of the eastern arm of Sacandaga Reservoir, will be seen at stop 3. For the most part, it is composed of beautifully layered, alternating light and dark bands. The thickness of these bands varies between inches and 2-3 feet. The light colored portions are composed of quartz, microcline, garnet, sillimanite, minor red biotite, and opaques. Modally the quartz content may be as high as 60%. The darker layers contain up to 15% biotite and the feldspar content includes some sodic plagioclase. Otherwise the compositions are similar.

In addition to the foregoing types of gneiss, the Sacandaga Fm. contains several thick sequences (50-100') of quartz-pyroxene-plagioclase granulites. Both ortho and clinopyroxenes are present in the modes.

Because of its excellent layering, the Sacandaga Fm. outcrops in striking flagstone-like sections which are unique in the stratigraphy and help to make the formation an easy one to trace in the field.

As the Sacandaga Fm. is followed westward on the north limb of the main culmination of the Piseco Anticline, calc-silicates begin to appear throughout the section. At Pumpkin Hollow (Stop 3) punky weathering layers of calcitic marble are exposed in a long roadcut. Farther to the west calc-silicates and marble become increasingly abundant at the expense of the more pelitic units.

In the northern and western portions of the southern Adirondacks quartzo-feldspathic gneiss "a" is exposed in the cores of the Oregon and Snowy Mt. Domes and in the Wakeley Mt. Nappe. In all these instances the overlying lithology is composed of interlayered marbles, garnetiferous amphibolites, quartzites, and light colored sillimanite-garnet-feldspar-quartz gneisses much like those dominating most of the Sacandaga Fm. These lithologies are collectively referred to as the Lower Marble Fm. (Walton and de Waard, 1963). The Lower Marble Fm. will be visited at Stop 1.

Stratigraphically the Lower Marble Fm. and the Sacandaga Fm. occupy the same relative position. The same is true geometrically, for the two formations occur in identical positions on opposite limbs of the Glens Falls Syncline. This suggests that they are very likely identical and grade into one another via a primary sedimentary facies transition. The increase of carbonate and calc-silicate material in the Sacandaga Fm. west of Pumpkin Hollow is consistent with this. Similarly, exposures of Lower Marble Fm. along the north limb of the Glens Falls Syncline are far richer in light colored sillimanite-garnet-feldspar-quartz gneisses than is normal in this unit. These gneisses are beautifully exposed along Route 30 just north of its junction with Route 8.

Although it has not yet been possible to map the Sacandaga and Lower Marble Fms. directly into one another, the relationships described above are considered adequate to adopt the indentity as real. Figure 10 shows the correlation.

Correlation of the Sacandaga and Lower Marble Fms. (fig. 5) is an important key to understanding all of the southern Adirondacks. In particular, it allows stratigraphy and structure south of the Piseco Anticline to be carried northward with no structural break demonstrating that the Canada Lake Nappe and the Little Moose Mt. Syncline are one and the same structure. This conclusion gains support from the fact that along the belt of Sacandaga Fm. lying on the far southwestern limb of the Piseco Anticline, there exist numerous calc-silicate pods, lenses, and layers. Similarly the Lower Marble Fm. lying on the northwestern limb of the Piseco Anticline contains little marble but does have relatively large quantities of quartzo-feldspathic gneisses in it. Evidently carbonate deposition was abundant only in the northern portions of the area, while sandy, pelitic lithologies dominated to the south.

Lying above the Lower Marble-Sacandaga Fm. is a considerable thickness of quartzo-feldspathic gneisses and charnockites known as the Lake Durant Fm. (deWaard, per.com.) In its lowermost parts it contains numerous bands of amphibolite, calc-silicate, rusty gneisses, and even marble. The upper 75% of the formation contains of rather well layered quartzo-feldspathic gneisses and thin amphibolites. It has been possible to follow this formation throughout the southern Adirondacks (fig. 5).

Directly above the Lake Durant Fm. there occurs a sequence of paragneisses named the Upper Marble Fm. by de Waard (Ibid). Lithologically this unit is much like the Lower Marble Fm. except that its lithologic variability appears to be greater. Within the southeastern Adirondacks the Upper Marble Fm. consists almost exclusively of sillimanite-garnet-biotite-quartz-feldspar gneisses known as kinzigites. Marble first appears in the section near Wells, N.Y. (fig. 2).

The next unit up in the stratigraphy is the Blue Mt. Fm. which consists of large thicknesses of massive charnockites with some paragneiss layers. The latter are particularly abundant in the Little Moose Mt. Syncline but are far less common in the southeastern Adirondacks. Because of this variability it has been difficult to precisely correlate the Blue Mt. Fm. with units south of the Piseco Dome. This uncertainty is doubly complicated by the fact that the Blue Mt. Fm. does not continue through the structural saddle at north of Sacandaga Reservoir and cannot, therefore, be mapped directly around the nose of the Piseco Anticline. The implicit correlation indicated on fig. 2 is presently preferred but by no means certain.

North of the Piseco Anticline the Blue Mt. Fm. appears to be the uppermost until in the stratigraphy. Whether or not this is so will depend upon detailed stratigraphic mapping in the eastern portion of the Glens Falls Syncline and correlation of this stratigraphy with de Waard's work in the Little Moose Mt. Syncline. South of the Piseco Anticline there exists a thick stratigraphic section that overlies all candidates for the Blue Mt. Fm. This section is dominated by kinzigites and charnockites. Quartzites are also common and 80% of the Irving Pond Formation (Stop 8) consists of pure, massive, vitreous quartzites. This formation cores the Canada Lake-Little Moose Mt. Nappe and is replete with beautiful minor F_1 folds.

The southern stratigraphy that overlies the Blue Mt. Fm., and is exposed south of the Piseco Anticline, has a thickness on the order of 10,000 meters. Tectonic thinning, thickening, and repetition make this figure approximate at

best. It is certain, however, that the section is of considerable extent. The reason it does not reappear to the north is because this portion of the stratigraphy is folded back to the south around the hinge line of the Canada Lake Nappe in the vicinity of the Piseco Anticline (fig. 6).

The Basement Controversy

In the early 1960's Walton and de Waard (1963) proposed an intriguing new hypothesis concerning Adirondack geology. They postulated that, together with associated charnockitic lithologies, the anorthositic rocks of the Adirondacks constituted a pre-Grenvillian basement complex. Prior to the Grenville Orogeny (~1.1 BY), this basement complex had been folded, metamorphsed, and eroded. Sometime during the Proterozoic the basement was unconformably overlain by the section of rocks that begins with the Lower Marble Fm. and is referred to as the supracrustal sequence. During the Grenville Orogeny, both basement and supracrustal sequence were folded together and metamorphosed. Subsequent erosion has left the basement exposed in the cores of domes, while the supracrustal rocks are preserved in synclinal keels.

The Walton-de Waard basement hypothesis was originally based upon the observation that the Lower Marble Fm. seems to overlie a number of different lithologies and appears, therefore, to be separated from these rocks by an unconformity. Presumably the unconformity was initially angular, but as in many other instances, the angular discordance had been erased by subsequent deformation.

There are several problems inherent in the basement hypothesis. The first is that a number of the so-called "older paragneisses" assigned to the basement complex are identical to lithologies lying above the marble. In this writer's opinion they should be included within the Lower Marble Fm. The fact that these units may often be discontinuous does not necessarily prove the existence of an erosional disconformity. The same affect could be produced by original variations in shallow water sedimentation. Even more probable is that boudinaging within the marble rich units would result in similar phenomena. It is widely recognized that boudinage structures are common in this horizon (Stop 1). In places the marbles have been almost completely squeezed out, and the Lake Durant Fm. lies directly on quartzofeldspathic gneisses of type "a", yet it is widely agreed that this sort of discordance is tectonic in origin.

A second point of importance concerns the status of the anorthositic gneisses as candidates for a pre-Grenvillian basement. Field work in the southern Adirondacks has resulted in the recognition of a large number of anorthositic sills that intrude at stratigraphic horizons lying far up into the supracrustal sequence. The locations of most of these are shown in fig. 10. One of these bodies will be visited at Stop 4. The existence of these sills represents serious negative information with regard to the hypothesis that the anothosites of the Adirondacks are part of a pre-Grenvillian basement. It is possible, of course, to suppose that there was more than one episode of anorthosite intrusion in the Adirondacks. However, even the principle bodies of anorthosite to the north contain inclusions of lithologies identical to the Lower Marble Fm. and appear to cause high temperature

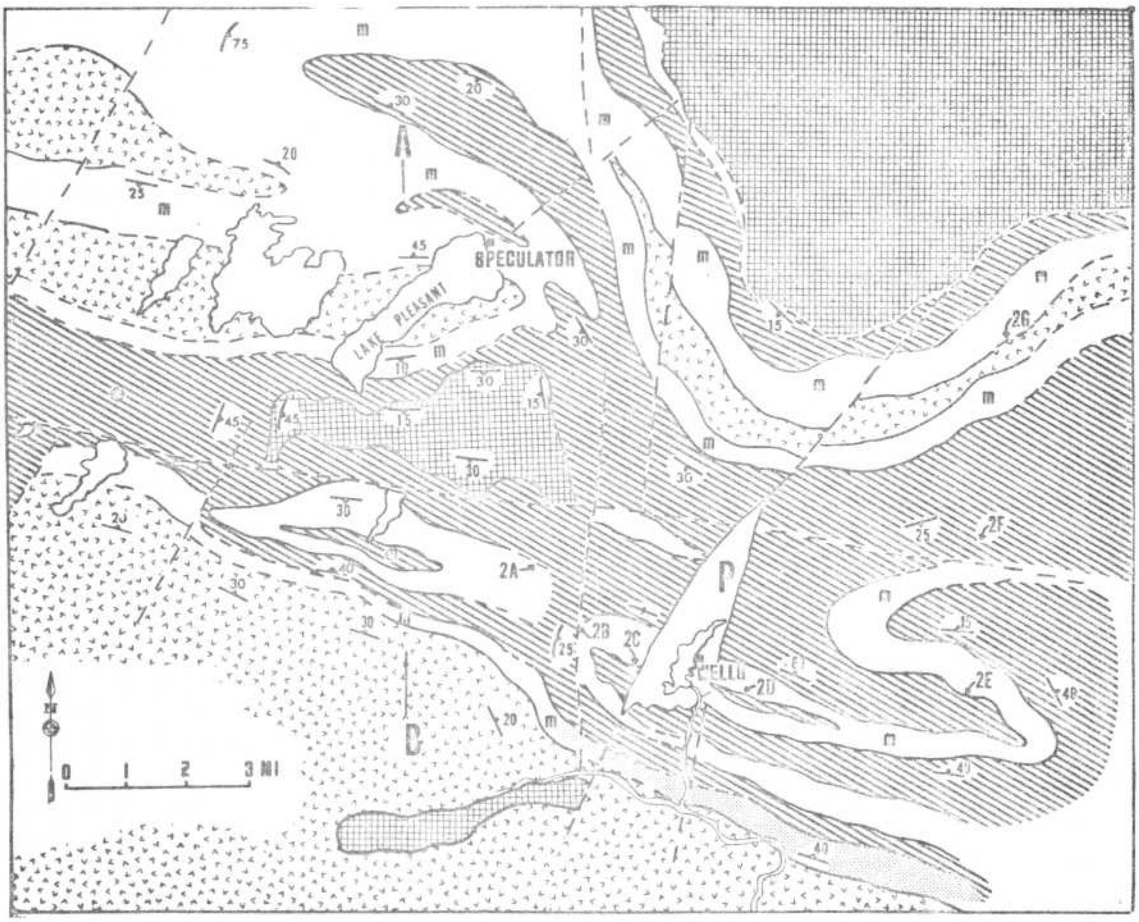


Figure 10 - Detailed geologic map of the area around Speculator and Wells, New York. Map patterns same as on fig. 2. Sites labelled 2A-2F locate anorthositic sills.

contact metamorphism in the latter, e.g. garnet-wollastonite deposits at Willsboro Point. Thus, all anorthosite bodies appear to post-date the Lower Marble Fm.

If we conclude that the anorthositic gneisses of the Adirondacks cannot be part of a Pre-Grenvillian basement, then it is still possible to hypothesize that the associated quartzo-feldspathic gneisses of type "a" constitute such a basement. Absolute age dating does not corroborate this hypothesis, and these gneisses may simply represent the next layer down in a continuous stratigraphy (Isachsen, McLelland, Whitney, 1975). However, the status of the type "a" gneisses remains unresolved, and the identification of a pre-Grenvillian basement constitutes a major problem in Adirondack research.

Faults

Three main systems of faults affect the Adirondacks. All are normal faults and many formed during the Precambrian and were reactivated in Paleozoic time. The best defined topographically is the NNE trending set that has been further accentuated by glacial scouring. A great many lakes are oriented parallel to this fault set, e.g. Indian Lake, Lake George. The NNE faults are important in determining the eastern and southeastern margins of the Adirondacks where they have "stepped-down" the Paleozoic section to the east. A number of grabens also exist. Such grabens are present at the Sacandaga Reservoir area, the Lake George Graben which continues southward to the northwest of Saratoga Springs, and at the Paleozoic inliers in the vicinity of Wells, N.Y.

The NNE faults often have extensive breccias developed along them. An outstanding example exists at, and just south of, the junction of Rts. 8 and 30. Many of these faults must have substantial offset along them, but, thus far, mapping of the Precambrian has failed to establish precise quantitative values for this displacement. The reason is that most of the larger NNE faults have major valleys associated with them, and it is difficult to extrapolate folded stratigraphy across these. A minimum offset is obtainable at the town of Wells where the Paleozoic inlier lies 1500 feet below the tops of the surrounding Precambrian hills. The offset must have been at least this much with the downthrown side being to the east.

Offset along the NW faults has been easier to ascertain because they are less affected by glacial scouring and resultant valleys. Near Canada Lake the offset on the western NW fault shown on fig. 2 is approximately 2000' with the east side being downthrown.

Slickensides, breccia, closely spaced fracturing, and stratigraphic discontinuities indicate that the region has been affected by an almost E-W set of high angle faults. Offset along these has not been measured. The E-W fault system shows up well on ERTS imagery and appears to extend into the Paleozoics.

Acknowledgements

The writer wishes to thank Yngvar Isachsen, Dirk de Waard, Philip Whitney, Leo Hall, and Ennis Geraghty for their insights, criticism, and encouragement. The following students have contributed greatly to the field mapping project: Stephen Goldberg, Richard Weiner, Richard Fahey, Jonathan Husch, Sue Dixon, Julie Milligan, Robert Peake, Bryan Luftglass, Jonathan Powell, Jonathan Chaffee, Karen Kleinspehn, David Muller, Bruce Douglas, Robert Kuhlman, Paul Dankwerth, Gil Wiswall, Lise Berlind, Graham Closs, David Howell, and Stanley Stoner.

This research has been funded by a National Science Foundation Research Grant, a National Science Foundation Faculty Science Fellowship, six National Science Foundation Undergraduate Research Participation Grants, the Sloan Foundation, and the Colgate University Research Council.

References

Balk, Robert, 1936, Structural and petrologic studies in Dutchess County, N.Y., Part I, Geol. Soc. Am. Bull., 47, 685-774.

Bartholome, Paul, 1956, Structural geology and petrological studies in Hamilton County, N.Y., Princeton University, doctoral thesis.

Buddington, A.E., 1939, Metamorphism of Adirondack igneous rocks, Geol. Soc. America, Mem. 7.

Cannon, R.S., Jr., 1937, Geology of the Piseco Lake quadrangle N.Y. State Mus. Bull. 312.

Cushing, H.P. and Ruedemann, R., 1914, Geology of Saratoga Springs and vicinity, N.Y. State Mus. Bull., 169.

deWaard, D., 1962, Structural analysis of a Precambrian fold: The Little Moose Mt. Syncline in the southwestern Adirondacks, Proc. Kon. Ned. Akad. Wetensch., Amsterdam, B, 65, 404-417.

_______, 1965, The Occurrence of Garnet in the Granulite-Facies Terrain of the Adirondack Highlands, Jour. Petrology 6, 1, 165-191.

Hall, Leo, et al., 1965, Northeastern edge of the Saratoga quadrangle, N.Y. State Mus. and Science Service, open-file maps.

Hills, Alan, 1965, The Precambrian Geology of the Glens Falls and Fort Ann quadrangles, Yale University, doctoral thesis.

Husch, J., Kleinspehn, K., McLelland, J., 1975, Anorthositic rocks in the Adirondacks: basement or non-basement? (abs) GAAPBC, 7, 1, p. 78.

Isachsen, Y., 1968, Crane Mt. area, North Creek quadrangle, N.Y. State Mus. and Science Service, open-file maps.

_______, McLelland, J. and Whitney, P., 1975, Anorthosite contact relationship in the Adirondacks and their implications for geologic history (abs.), GAAPCB 7, 1, p. 78.

Lettney, C., 1968, The anorthosite-charnockite-norite series of the Thirteenth Lake Dome, south-central Adirondacks, in, Isachsen, ed. Origin of anorthosite and related rocks, N.Y. State Mus. and Science Service, Mem. 18.

Miller, W.J., 1911, Geology of the Broadalbin quadrangle, N.Y. State Mus. Bull., 153.

_______, 1916, Geology of the Lake Pleasant quadrangle, N.Y. State Mus. Bull., 182.

_______, 1920, Geology of the Gloversville quadrangle, N.Y. State Mus. and Science Service, open-file maps.

_______, 1923, Geology of the Luzerne quadrangle, N.Y. State Mus. Bull., 245-46.

McLelland, J., 1969, Geology of the southermost Adirondacks, NEIGC Guidebook 61, 11-1 - 11-34.

_______, 1972, Stratigraphy and structure of the Canada Lake Nappe, NYSGA Guidebook 44, E1-E27.

_______, 1973, Structural framework of the southern Adirondacks (abs.) GAAPBC 5, 1, p. 54.

_______, 1974, Structure and stratigraphy of the southern Adirondacks (abs.) GAAPBC, 6, 7, p. 865.

_______, and Whitney, P., 1976, Origin of garnet coronas in the anorthosite-charnockite suite of the Adirondacks (abs.), in press.

Nelson, A.E., 1968, Geology of the Ohio quadrangle, U.S. Geol. Survey Bull., 1251-F.

Thompson, B., Jr., 1959, Geology of the Harrisburg quadrangle, N.Y. State Mus. and Science Service, open-file maps.

Walton and de Waard, 1963, Orogenic evolution of the Precambrian in the Adirondack highlands: a new synthesis, Proc. Kon. Ned. Akad. Wetensch., Amsterdam, B, 66, 98-106.

Whitney, P. and McLelland, J., 1973, Origin of coronas in Adirondack metagabbros, Contr. Min. & Petrol., 39, 81-98.

Road Log

See Figure 3 for Stop Locations

Mileage

0 Center of Speculator, N.Y. Junction Rt. 8 and Rt. 30. Head east on Rt. 8-30.

3.3 Stop 1. Northern intersection of old Rt. 30 and new Rt. 30, 3.3 miles east of Speculator, N.Y.

The Lower Marble Fm. is exposed in roadcuts on both sides of the highway. These exposures show typical examples of the extreme ductility of the carbonate rich units. The south wall of the roadcut is particularly striking, for here relatively brittle layers of garnetferous amphibolite have been intensely boudinaged and broken. The marbles, on the other hand, have yielded plastically and flowed with ease during deformation. As a result the marble-amphibolite relationships are similar to those that would be expected between magma and country rock. Numerous rotated, angular blocks of amphibolite are scattered throughout the marble in the fashion of xenoliths in igneous intrusions. At the eastern end of the outcrop tight isoclinal folds of amphibolite and metapelitic gneisses have been broken apart and rotated. The isolated fold noses that remain "floating" in the marbles have been aptly termed "tectonic fish".

Features such as those seen within this roadcut have led this writer to question the appropriateness of assigning an unconformity to the base of the Lower Marble Fm. Tectonic phenomena in rocks of high viscosity contrast can account for the fact that the marbles are able to come into contact with a variety of lithologies.

A variety of interesting lithologies are present in this roadcut. The marble itself contains diopside (now serpentinized), tourmaline, graphite, chondrodite, phlogopite, and a variety of pyrites. Interesting reaction rims, or selvages, exist between the marbles and quartz rich boudins. Presumably these selvages reflect the influence of compositional gradients during metamorphism.

Most of the amphibolites in the outcrop are highly garnetiferous and some layers appear to contain 60-70% garnet. The garnets are almandine rich and are similar to those at Gore Mt. However, it is not known whether these amphibolites represent metamorphosed sedimentary or igneous rocks. Note that a number of the garnets are separated from surrouding hornblende by narrow light colored rims. These consist of calcic plagioclase and orthopyroxene and represent products of the reaction:

Garnet + Hornblende = Orthopyroxene + Calcic Plagioclase + Water

This reaction is characteristic of the granulite facies wherein the association garnet plus hornblende is unstable (de Waard, 1965).

Also present in the outcrop are various layers rich in calc-silicates. One of these contains coarse, white diopside crystals several inches across. Others consist almost entirely of green diopside. Tremolite has also been found in some layers. Rusty weathering, metapelitic units are rich in graphite, calc-silicates, and pyrite.

Near the west end of the outcrop a deformed layer of charnockite is well exposed. In other places the charnockite-marble interlayering occurs on the scale of one to two inches.

Exposed at several places in the roadcut are striking, cross-cutting veins of tourmaline and quartz displaying a symplectic type of intergrowth. Other veins include hornblende and sphene bearing pegmatites.

Commonly included in the Lower Marble, but not exposed here, are quartzites, kinzigites; sillimanite rich, garnitferous, quartz-microcline gneisses; and fine grained garnetferous leucogneisses identical to those characterizing the Sacandaga Fm. These lithologies may be seen in roadcuts .5 mile to the south.

Almost certainly these marbles are of inorganic origin. No calcium carbonate secreting organisms appear to have existed during the time in which these carbonates were deposited ($\sim$1.1 BY ago). Presumably the graphite represents remains of stromatolite-like binding algae that operated in shallow water, inter-tidal zones. If so, the other roadcut lithologies formed in this environment as well. This seems reasonable enough for the clearly metasedimentary units such as the quartzites and kinzigites. The shallow water environment is much more interesting when applied to the charnockitic and amphibolite layers. The fine scale layering, and ubiquitous conformity of these, strongly suggests that they do not have an intrusive origin. Perhaps they represent the metamorphosed products of volcanic material in a shelf like environment. Such intercalation is now occurring in many island arc areas where shallow water sediments cover, and in turn are covered by, ash and lava. Alternatively they may represent metasediments.

3.8 On west side of road are extensive cuts in the Lower Marble Fm. Quartzite, calc-silicate, and sillimanite-garnet-quartz-feldspar leucogneisses are especially well developed here. Some marble and charnockite are present. The large hills to the southeast consist of anorthositic gneisses in the Oregon Dome. The rocks exposed along the highway dip off the dome.

4.3 Large roadcuts in the Lake Durant Fm. The dominant lithology is well banded, pink quartzo-feldspathic gneiss. Layers of amphibolite and calc-silicate are present near the base of the roadcut. On the east side of the road rusty, calc-silicate gneisses are present.

5.4 Stop 2. One half mile south of southern intersection of old Rt. 30 with new Rt. 30.

On the west side of the road small roadcut exposes a splendid example of Adirondack anorthositic gneisses that are intermediate in character between the so-called Marcy type (uncrushed) and the Whiteface type (crushed). About 50% of the rock consists of partially crushed crystals of andesine plagioclase. Some of these crystals appear to have measured from 6"-8" prior to cataclasis. Excellent moonstone sheen can be seen in most crystals. In places ophitic to subophitic texture has been preserved with the mafic phase being represented by orthopyroxene.

In addition to the coarse grained anorthosite there exists a fine grained phase and a clearly crosscutting set of late orthopyroxene rich dikes. The latter may represent a late mafic differentiate related to cotetic liquids responsible for the ophitic intracrystalline rest magma. This would be consistent with the iron enrichment trend characteristic of Adirondack igneous differentiation. The fine grained phase may have intruded early in the sequence, but this is uncertain.

Near road level there can be found several inclusions of calc-silicate within the anorthositic rocks. These are believed to have been derived from the Lower Marble Fm. and are consistent with a non-basement status for the anorthosite.

The upper, weathered surface of the outcrop affords the best vantage point for studying the textures and mineralogy of the anorthositic rocks. In several places there can be seen excellent examples of garnet coronas of the type that are common throughout Adirondack anorthosites. These coronas are characterized by garnet rims developed around iron-titanium oxides and pyroxenes. Recently McLelland and Whitney (1976) have succeeded in describing the development of these coronas according to the following generalized reaction:

Orthopyroxene + Plagioclase + Fe-bearing oxide + quartz = garnet + clinopyroxene

This reaction is similar to one proposed by de Waard (1965) but includes Fe-oxide and quartz as necessary reactant phases. The products are typomorphic of the garnet-clinopyroxene subfacies of the granulite facies (de Waard, 1965). The application of various geothermometers to the phases present suggests that the P,T conditions of metamorphism were approximately 8Kb and 650°-$700^{\circ}C$ respectively.

5.8 Re-enter the Lake Durant Fm.

7.3 Re-enter the Lower Marble Fm. For the next mile excellent sillimanite-garnet-quartz-feldspar leucogneisses are exposed. Garnetiferous amphibolite is also present and a little marble can be found near the north end of this exposure. The leucogneisses are similar to those in the Sacandaga Fm.

8.3 Junction of Rts. 8 and 30. On the west side of the road are leucogneisses of the Lower Marble Fm. A large NNE normal fault passes through here and striking breccias can be found. This fault continues south to Wells where it is responsible for down dropping an inlier of Paleozoic rocks.

8.8 Upper Marble Fm. in woods to west. Now entering the Blue Mt. Fm. Dips are to the south as we are on the north limb of the Glens Falls Syncline.

11.3 Junction with Gilmantown Rd. The large hills to the southwest lie on the north flank of the Piseco Anticline. Continue south into Wells. Wells is underlain by Paleozoic sediments. The minimum displacement of the implied downfaulting must be at least as great as the difference in elevation between Wells and the surrounding Precambrian hills (1500').

14.8 Silver Bells Ski area to east. The slopes of the ski hill are composed of excellent gabbroic anorthosite and anorthositic gabbro. These appear to be intrusive into the Upper Marble Fm.

16.8 Entrance to Sacandaga Public Campsite. On the north side of the road are quartzo-feldspathic gneisses and cal-silicates. These are probably within the Lower Lake Durant Fm. Anorthositic and gabbroic rocks have intruded here and locally steep dips may be related to this.

18.4 Stop 3. Pumpkin Hollow. Large roadcuts on the east side of Rt. 8-30 expose excellent examples of the Sacandaga Fm. At the northern end of the outcrop typical pyroxene plagioclase granulites can be seen. The central part of the outcrop contains good light colored sillimanite-garnet-microcline-quartz gneisses (leucogneisses). Although the weathered surface of these rocks may be dark due to staining, fresh samples display the typical light color of the Sacandaga Fm. The characteristic excellent layering of the Sacandaga Fm. is cearly developed.

Towards the southern end of the outcrop calc-silicates and marbles make their entrance into the section. At one fresh surface a thin layer of diopsidic marble is exposed. NO HAMMERING, PLEASE.

At the far southern end of the roadcut there exists a singular, and important, exposure. Here one can see exposed the contact between the quartzo-feldspathic "a" gneisses of the Piseco Anticline and the overlying Sacandaga Fm. The hills to the south are composed of homogeneous quartzo-feldspathic type "a" gneisses coring the Piseco Anticline (Note how ruggedly this massive unit weathers). The Sacandaga Fm. at Stop 3 has a northerly dip off the northern flank of the Piseco Anticline and begins its descent into the Glens Falls Syncline.

No angular discordance or metamorphosed soil profile can be discerned at the base of the Sacandaga Fm. However, this does not preclude the prior existence of an angular discordance. Intense deformation often erases all traces of earlier angular discordance (Balk, 1936).

Along most of the roadcut there can be found excellent examples of faults and associated pegmatite veins. Note that the drag on several of the faults gives conflicting senses of displacement. The cause of this is not known to the author. Also note the drag folds which indicate tectonic transport towards the hinge line of the Piseco Anticline.

18.9 For the next 4 miles all exposures are within the quartzo-feldspathic "a" gneisses of the Piseco Anticline.

22.9 Re-enter Sacandaga Fm. Dips are now southerly since we are on the south flank of the Piseco Anticline.

26.4 Cross the Sacandaga River. From the last log entry to here all exposures have been within the Sacandaga Fm. The large hills immediately to the south are underlain by vertically dipping paragneisses and metagrabbros situated on the hinge line of the Canada Lake Nappe.

30.3 Turn west on bridge into Northville, N.Y.

30.9 Stop Sign. Turn south.

31.9 Stop Sign. Stright ahead.

40.05 Turn right.

40.25 Turn left.

41.05 Turn right on Airport Road.

41.4 Turn left on Bradt Hill Road.

42.2 Turn left on Military Road.

42.5 Stop 4. Tenantville Complex. The Tenantville Complex consists of a number of metagabbroic and meta-anorthositic sheets (sills?) that have been intruded into the stratigraphy occupying the structural saddle at the east end of the main portion of the Piseco Anticline (figs. 2, 3). These rocks vary in composition from amphibolite to gabbroic anorthosite. Typical modes, analyses, and norms are shown in Table 1. Accompanying these are similar data for anorthositic rocks from the Marcy Massif. Clearly the Tenantville intrusives are part of the anorthositic suite. At Stop 4 their texture and general appearance are quite similar to rocks characteristic of the White face type anorthosite.

As shown are Figs. 2 and 3 from the rocks within this structural saddle range from the Lower Marble to the Upper Marble Fm. The Tenantville Complex intrudes Lake Durant and Upper Marble equivalents and demonstrates why the anorthositic rocks of the Adirondacks are not candidates for pre-Grenvillian basement. The Tenantville Complex is thought to be stratigraphically continuous with similar rocks within the Upper Marble Fm. south of Piseco Lake and also those immediately east of the town of Wells (fig. 3).

47.1 Junction Military Road with Yates Hill Road. Turn right.

49.25 Intersection Yates Hill Road and North Shore Road. Turn north to Day Center.

49.75 Cross Paul Creek heading east.

Table 1. MODAL ANALYSES

	Tenant-ville[1]	Tenant-ville[2]	Average Anor-thositic Gabbro[1]	White-Face Type A[2]	White-Face Type B[3]
Plagioclase	51.73	77.42	62.2	73.0	81.2
K-Feldspar	-----	Tr	1.0	2.0	1.6
Amphibole	37.19	15.14	0.9	4.0	0.5
Biotite	4.68	Tr	1.5	1.5	Tr
Pyroxene	Tr	0.27	20.9	7.0	7.1
Quartz	1.00	0.72	1.8	3.0	1.0
Garnet	3.07	2.62	6.6	7.0	2.7
Opaque	1.12	3.53	2.2	2.0	2.3
Apatite	1.83	0.45	1.1	0.5	0.4

1,2,3) Buddington, 1939, Table 5: 1) Average of 5; 2) Average of 20, contaminated; 3) Average of 21, uncontaminated.

Table 2. PLAGIOCLASE AND ORTHOPYROXENE COMPOSITIONS

	OPX (% En)	PLAG (% An)
Tenantville 2	--	55
Tenantville 3	--	53
Average Whiteface Type	En_{60-75}[1]	An_{44}[2] An_{55}
Average Marcy Type	En_{60-75}[1]	An_{44}[2] An_{57}

1) Anderson and Morin, 1969, fig. 1. 2) Crosby, 1969, Tables 1 and 2. Higher value for megacripts; lower value for crushed groundmass.

50.35 Type exposures of the Sacandaga Fm. Steep cliffs on north side of road are all Sacandaga Fm. Quartzo-feldspathic "a" gneisses of Piseco Anticline are exposed near water level of reservoir. The strike of foliation is parallel to the road and dips average 30^o-40^o N. For the next 3.2 miles all roadside exposures are in the Sacandaga Fm. Across the reservoir, to the south, the hills are composed of quartzo-feldspathic "a" gneisses in the core of the Piseco Anticline.

53.55 Contact of the Sacandaga Fm. with the quartzo-feldspathic gneisses of the equivalent of the Lake Durant Fm.

57.05 Stop 5. Conklingville Dam. Conklingville Dam affords an unparalleled opportunity to inspect the lithologies and structures present in an Adirondack kinzigite. The Glossary of Geology defines kinzigite as "A coarse grained metamorphic rock of pelitic composition occurring in the granulite facies. Essential minerals are garnet and biotite with varying amounts of quartzo, K-feldspar, oligoclase, muscovite, cordierite, and sillimanite." Except for muscovite this definition aptly describes the rocks at Conklingville Dam. Elsewhere in the southern Adirondacks, kinzigites are closely similar to these. Invariably occurring within them are pods, lenses, and cross-cutting veins of light colored two feldspar-quartz compositions. These are believed to be anatectic in origin.

Kingzigite is very abundant in the Adirondacks south of the Piseco Anticline. It dominates among the definitely metasedimentary units. This is in contrast to the areas north of the Piseco Anticline where kinzigites are fairly uncommon. This difference is due both to the absence of units about the Blue Mt. Fm. in the northern section as well as to the sedimentary facies change to carbonate rich lithologies in the lower stratigraphy.

In general the kinzigites show considerable ductile behavior during deformation (though not nearly as much as the marble). As a consequence, they contain numerous minor folds and present excellent opportunities for studying deformational style and history on a small scale. Many fine examples of such structures can be seen at Conkinglingville Dam. Several instances of refolded folds are present as well as folded foliation. Axial plane foliation is well developed. On a larger scale, the steeply dipping foliation planes lie on the northern limb of the Piseco Anticline. As at Pumpkin Hollow, drag folds related to the Piseco structure can be seen at several places.

It is thought that the kinzigites represent metamorphosed equivalents of shales or siltstones.

58.25 Jeffers Mt. to the north.

60.95 Cross Hudson River at Luzerne. Kinzigites in riverbed.

61.15 Junction Rt. 9. Turn S. to Corinth.

66.15 Center of Corinth, N.Y. Continue south along Main Street.

69.15 Randall's Corners.

69.52 Junction with Speir Falls Road. Turn north.

72.12 Stop 6. Speir Falls on the Hudson River. At Speir Falls the Hudson River has incised itself into the core of the easternmost culmination of the Piseco Anticline. As a result the quartzo-feldspathic "a" fgneisses are well exposed along the roadside. Structurally we are at the crest of the anticline and good lineation can be observed.

Within the Piseco Anticline the quartzo-feldspathic "a" gneisses consist principally of two feldspar-quartz lithologies which are analogous to quartz monzonite compositions in igneous rocks (Note: this statement is not meant to imply an igneous origin for these gneisses. Their pre-metamorphic origin is, as yet, obscure). Biotite, hornblende, garnet, and occasional orthopyroxene are common minor phases. In many exposures the gneisses are highly flattened in the foliation plane and show an extremely strong mineral lineation parallel to the fold axis. In these exposures the rocks are generally equigranular and of moderate to fine grain size. The flattened foliation is almost certainly the result of the early F_1 folding. The F_2 folding of the Piseco Anticline clearly folds this foliation. F_2 foliation may be found transecting the F_1 foliation at a large angle. The lineation is probably of F_2 origin, in part, but this is more difficult to ascertain, because F_1 and F_2 were essentially coaxial. In several instances rodding can be recognized as hinge lines of closely oppressed F_1 minor folds. However, not all rodding is of this sort. It is possible that the unusually strong lineation on the F_2 hinge lines reflects the fact that approximately parallel F_1 and F_2 lineations combine here to give an effect that is "twice" as intense as elsewhere. This, however, is speculative.

In many instances it is possible to demonstrate that the equigranular portions of the quartzo-feldspathic "a" gneisses are crushed, cataclastic equivalents of inequigranular quartzo-feldspathic gneisses that are common in many quartzo-feldspathic lithologies of the southern Adirondacks. These inequigranular gneisses are best represented by the Rooster Hill Fm. of the Canada Lake area (McLelland, 1972) and by the Hermon Granite gneiss of the northwestern Adirondacks (Buddington, 1939). In these gneisses (particularly the former) megacrysts of perthite or microcline perthite may attain lengths of as much as 4". These are almost always flattened in the plane of foliation and are occasionally rotated. Even so the megacrysts often retain a subhedral appearance This investigator prefers a metamorphic origin for the megacrysts. This, however, is extremely uncertain.

Field mapping has shown numerous instances in which the inequigranular, megacrystic gneisses grade into the equigranular varities via cataclasis. All stages of intermediate types can be recognized in the field. Examples may be seen at Speir Falls. It thus appears possible, although by no means proven, that many, if not most, of the equigranular quartzo-feldspathic gneisses of both "a" and "b" types were originally inequigranular prior to deformation. The mapping of gradations between the textural varieties constitutes an important aspect of future research.

In every case examined the quartzo-feldspathic gneisses of the southern Adirondacks have displayed stratigraphic conformity. No cross-cutting contacts have been recognized. If these rocks are of igneous parentage, they must have been intruded as sills or represent metavolcanics. A metasedimentary parentage is also possible. Although their origin is obscure, that presence of stratigraphic conformity serves as an important boundary condition on any mode of evolution.

Continue north on Speir Falls Road.

74.02 Stop 7. Paragneisses flanking the Piseco Anticline.

Exposed in this roadcut are excellent examples of rusty, graphitic paragneisses and kinzigites. These are generally sillimanite bearing. The steep dips are associated with the north flank of the Piseco Anticline.

Stratigraphically these units appear to correspond to the Upper Marble Fm.

Continue northeast on Speir Falls Road.

75.16 Junction Potter Road. Turn Right (east).

75.54 Bear right (SE) on Mountain Road.

75.92 Saratoga Road. Proceed south.

76.22 South Road. Proceed south.

76.47 Junction Rt. 9. Turn south.

81.22 Turn west on Gailor Road.

81.6 Intersect Greene Road. Proceed west.

82.00 Stop 8. Irving Pond Fm. at Greene Road.

Exposed in this stream are typical examples of the Irving Pond Fm. Thick, massive quartzites dip gently to the south. Garnets and calc-silicate layers are occasionally present. The quantity of quartzite is, in itself, impressive.

The Irving Pond Fm. is named for its type exposures near Canada Lake (McLelland, 1972). There, as well as at this stop, the Irving Pond Fm. cores the Canada Lake Nappe. As shown in fig. the Irving Pond has been folded back on itself. Whether or not an overlying lithology was squeezed out of the axial region of the nappe is unknown. In any case, the axial trace of the nappe may be followed from the vicinity of Canada Lake to the northeastern margin of the Adirondacks on which we are now located. This involves a horizontal distance of approximately 70 miles (105 km). A fold of such dimensions is truly of regional extent. Given the correlation of the Canada Lake Nappe with the Little Moose Mt. Syncline, the amplitude of this structure is in the range of 40-50 miles (60-80 km).

As suggested in fig. 7 this fold, and the associated Wakeley Mt. Nappe, are very likely to exceed even these unusually large dimensions. Deep seated nappes of this size are rarely exposed. Some of the Pennine nappes of the Alps may be reasonable analogies and do attain similar dimensions.

Based upon de Waard's (1965) assignment of relative ages in the Little Moose Mt. Syncline, and given the regional correlations described in this paper, it follows that the Canada Lake--Little Moose Mt. is synclinal and the Irving Pond Fm. is the youngest unit in the stratigraphy (fig. 6).

End Road Log

TRIP B

MUSEUMS, GEOLOGY AND EDUCATION: FROM OLD TO NEW

IN

THE NEW YORK STATE MUSEUM

by

Trip Coordinator:

Judith M. Jesse
Senior Museum Exhibit Planner
New York State Museum

Speakers:

Donald W. Fisher, State Paleontologist
M. Raymond Buyce, Senior Scientist and Curator of Geology
Paul L. Weinman, Museum Education Supervisor
Judith M. Jesse, Senior Museum Exhibit Planner
Verna Ezard, Museum Exhibit Technician
Keith Metzler, Chief, Design & Production

DRIVING INSTRUCTIONS

Stop #1

"Old" New York State Museum
Fifth Floor
State Education Building
Washington Avenue
Albany, New York

From Skidmore College, return to I-87 (Northway) going south to Albany. Leave I-87 at Exit 1-E Albany & I-90 (east). Take I-90 east to the junction with I-787. Follow the signs that say I-787, Rensselaer, Troy, Albany and I-787 South, Albany, Rensselaer onto I-787 south. Exit at Clinton Avenue, then follow signs to Broadway. Turn left onto Broadway, travel several blocks and turn right onto State Street--Route 5. Follow Route 5 going up State to Eagle Street, turning right and swinging left onto Washington Avenue. The white marble, columned State Education Bldg is on the right side of Washington Avenue, between Hawk & Swan Streets. Park on the street in front of the building. Do not park in front of fire hydrants, but you may ignore the "No Parking" and bus parking signs as tickets are not usually issued on Saturdays. Go up the steps at the center of the Education Bldg. and enter through the main door. Take elevator to 5th floor.

Stop #2

New York State Museum
Exhibits Center
60 Commerce Avenue
Albany, N.Y.

Take Route 5 back to State Street and turn right onto Broadway. Go a few blocks and turn left following signs for I-787 North (Troy). Go north on I-787 to the junction with I-90 Boston & Buffalo. Follow the signs for I-90 (west) Buffalo. Continue west on I-90 to Exit 5, Everett Road. Turn left onto Everett Road, then turn left onto Watervliet Avenue Extension. This is just past the I-787 interchange; there is no traffic light but you will see the Quality Inn. After one block, the Extension becomes Commerce Avenue. The Exhibit Center is a long warehouse-style building on the right, just across from the Crowley Dairy. Park at the main entrance, near Rawson Street.

Stop #3

New York State Museum
Cultural Education Center
Empire State Plaza
Albany, N.Y.

Go back to Everett Road, turn right and then take the next right onto I-90 east. Go to the junction with I-787. Follow the signs that say I-787, Rensselaer, Troy, Albany and I-787 South, Albany, Rensselaer onto I-787 south. Exit at the Port of Albany, Madison Avenue, Route 20 West. Exit and get onto Madison Avenue. Go straight up Madison Avenue (Routes 9&20) to Eagle Street. You will see a large church with the Cultural Education Center behind it. Turn left onto Eagle Street, then turn right at the next corner onto Park Ave. Near the end of the block on the right, is a Mall Construction entrance, with an old wooden shack

Stop #3 (continued)

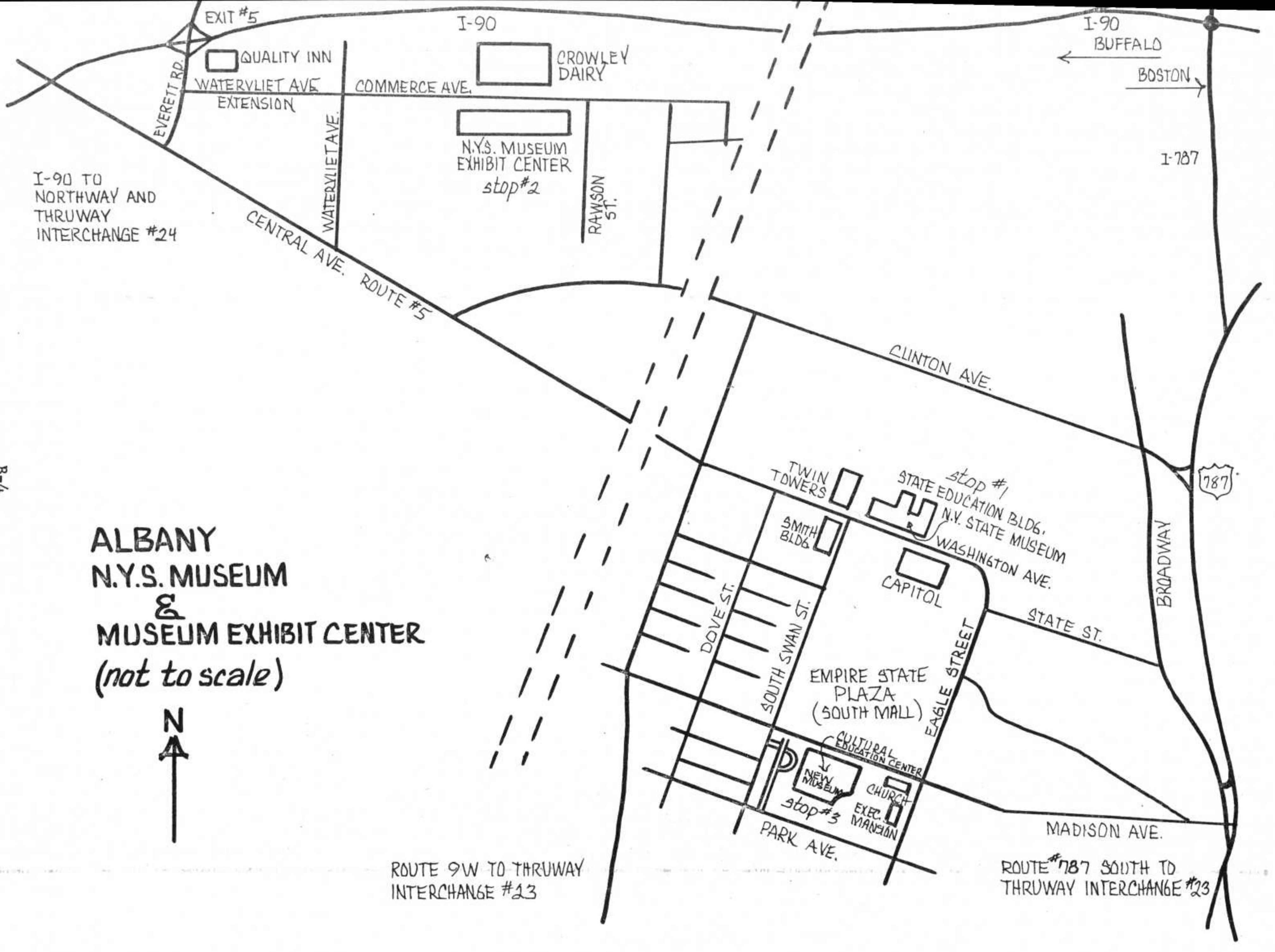
and a badly weathered sign which says South Mall, Gate 35. Turn right into this entrance and go straight until you are beside the Cultural Center. Then follow the first dirt path down to the side of the building. Park near the wooden "elephant doors" and enter through the small, wooden door.

To leave Albany:

Follow the dirt road uphill from the new Museum. And follow the road to Swan Street. Turn right onto Swan Street, cross Madison Avenue, then stay left and follow the signs for I-787. You will go under the Empire State Plaza and take a long ramp to I-787.

Go north to I-90, the Northway (I-87) and the Thruway West.

Go south to the Thruway.

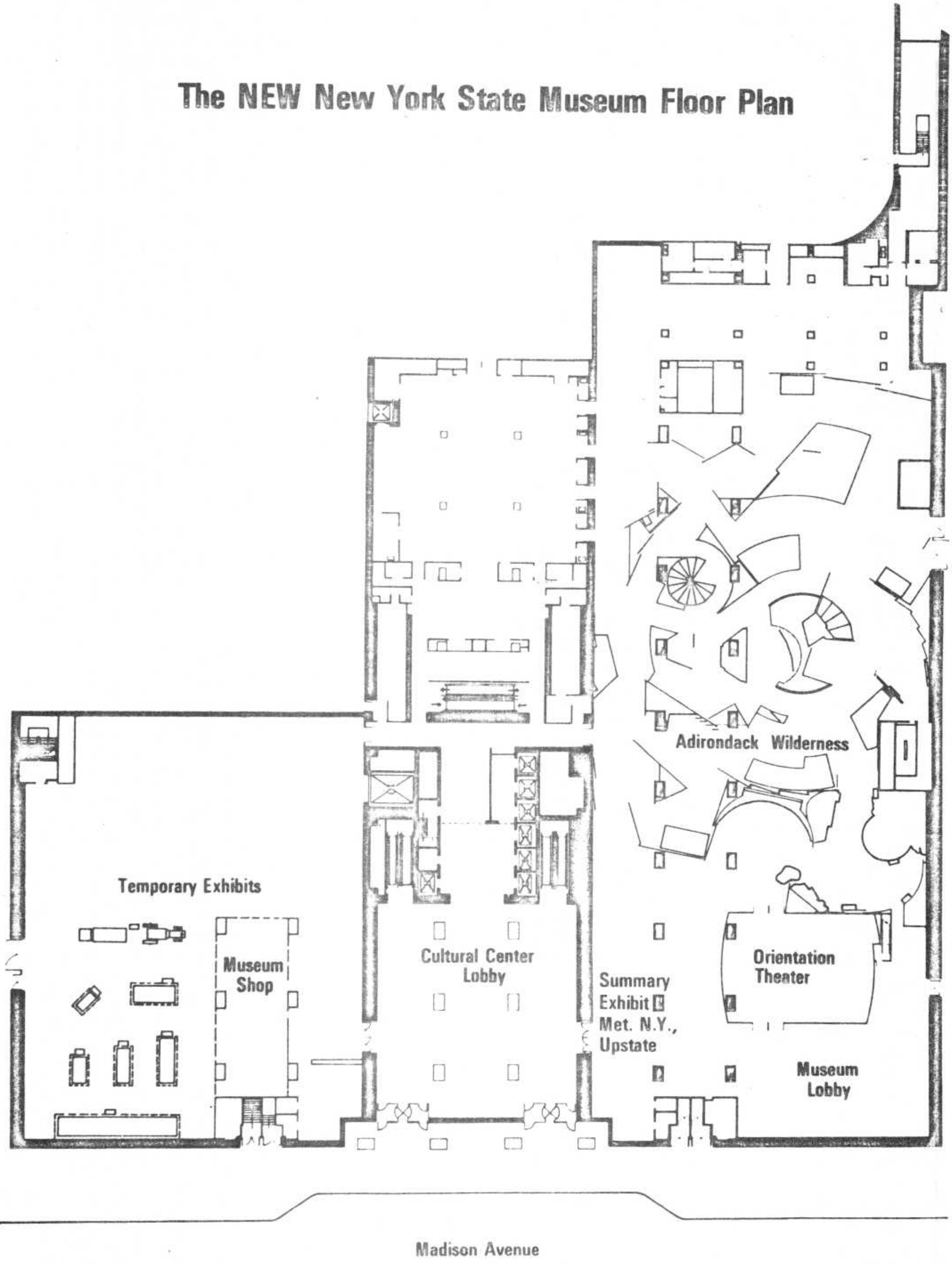

ALBANY
N.Y.S. MUSEUM
&
MUSEUM EXHIBIT CENTER
(not to scale)
N
EXIT #5
I-90
I-90
BUFFALO
BOSTON
QUALITY INN
CROWLEY DAIRY
EVERETT RD.
WATERVLIET AVE EXTENSION
COMMERCE AVE.
WATERVLIET AVE.
N.Y.S. MUSEUM EXHIBIT CENTER
stop #2
RAWSON ST.
I-787
I-90 TO NORTHWAY AND THRUWAY INTERCHANGE #24
CENTRAL AVE. ROUTE #5
CLINTON AVE.
787
TWIN TOWERS
stop #1
STATE EDUCATION BLDG.
N.Y. STATE MUSEUM
SMITH BLDG.
WASHINGTON AVE.
CAPITOL
BROADWAY
STATE ST.
DOVE ST.
SOUTH SWAN ST.
EAGLE STREET
EMPIRE STATE PLAZA (SOUTH MALL)
CULTURAL EDUCATION CENTER
NEW MUSEUM
CHURCH
stop #3
EXEC. MANSION
PARK AVE.
MADISON AVE.
ROUTE 9W TO THRUWAY INTERCHANGE #23
ROUTE #787 SOUTH TO THRUWAY INTERCHANGE #23

MUSEUMS, GEOLOGY AND EDUCATION: FROM OLD TO NEW
IN THE NEW YORK STATE MUSEUM

Trip Coordinator: Judith M. Jesse
Senior Museum Exhibit Planner
New York State Museum

Stop #	Time	Location	Speaker/Event
1		"Old" New York State Museum Fifth Floor State Education Building Albany, N.Y.	
	9:30 a.m.		A Museum with a Past and Present Dr. Donald W. Fisher, State Paleontologist Dr. M. Raymond Buyce, Senior Scientist (Curator of Geology)
	10:30 a.m.		Adventures in Learning Paul L. Weinman, Museum Education Supervisor
	11:00 a.m.		Tour of Museum (self-guided)
2		New York State Museum Exhibits Center 60 Commerce Avenue Albany, N.Y.	
	12:15 p.m.		Lunch (Bring your own)
	1:00 p.m.		A Museum with a Future - The New Exhibit Program Judith M. Jesse, Senior Museum Exhibit Planner
	1:30 p.m.		The Business of Exhibits Preparation Verna Ezard, Museum Exhibit Technician
3		New York State Museum Cultural Education Center Empire State Plaza Albany, N.Y. (Open to Public, July 1, 1976)	
	3:00 p.m.		Tour of Adirondack Wilderness Hall of new State Museum Keith Metzler, Chief, Design & Production

The NEW New York State Museum Floor Plan



THE NEW YORK STATE MUSEUM
Science Service
Museum Services
Historical Services

The New York State Museum, the oldest and largest state museum in the nation, performs a three-fold task. It collects and preserves specimens that form the tangible and irreplaceable record of the State's human and natural history; it conducts research; and it interprets the history and science of New York by means of exhibits, lectures, school programs, films, and publications.

The Museum's origin was in the Geological and Natural History Survey which the Legislature initiated in 1836 to examine the State's resources. Ardent young scientists returned with numerous crates and barrels of specimens. To take custody of these, the Legislature in 1843 established a State Cabinet of Natural History. Row upon row of "natural curiosities" were displayed and were soon joined by Iroquois relics assembled by Lewis H. Morgan of Rochester. The Cabinet was upgraded in 1871 into the New York State Museum of Natural History, with Dr. James Hall, world renowned paleontologist and geologist, as director. He set the pace for scientific research and collection of specimens.

Until 1912, when the State Education Building was completed, the museum collections were scattered around Albany, displayed in at least eight different buildings, including the Capitol. Since then, the exhibits have occupied the fifth floor of the columned State Education Building. Here, stepping from the elevator, visitors peered into the re-created Gilboa seed-fern forest of Devonian time. Photographs of this forest setting illustrated several introductory geology textbooks in the 1960's and therefore the scene is familiar to students all over America. The thousands of adults and children who visited the Museum saw a profusion of ore and mineral specimens, fossils and dioramas of ancient environments, the reassembled Cohoes Mastadon, naturalistic exhibits of beaver, deer, and other modern animals in their habitats, plus the very popular and life-like exhibits of Iroquios Indians. You will tour this Museum at Stop #1.

Many museum exhibition techniques like the Indian dioramas were pioneered or perfected here to give dramatic impact to exhibits. Yet, in order to perform at its fullest potential, the Museum needed a building designed more specifically for use as a museum, with facilities for larger exhibits, study collections, research laboratories, and classrooms. Requests for such facilities, first made in 1916, were only partially satisfied by the addition of the annex to the State Education Building in 1960.

At last, the Museum's new home will open in the New York State Cultural Education Center on the Empire State Plaza on July 1, 1976. The Center will house the Science Service, the Division of Historical Services and the State Library, as well as the Museum.

Many of the old Museum's specimens furnish subjects for the new Museum. Already, Adirondack ore samples, the moose, the timber wolf, and the peregrine falcon are installed in new exhibits. The World of Gems, a new exhibit in the old building, will have a prominent place in the new Museum.

It is not possible to incorporate all of the old exhibits into the new Museum. Certain ones, such as the Gilboa forest, were constructed in place and cannot be moved. Others do not contribute to the theme of the new Museum which is Man and Nature in New York State. Some exhibits will be offered to other institutions for educatinal use. Some will be disassembled and absorbed into the scientific and historical collections where students and specialists will be able to study individual specimens.

THE NEW STATE MUSEUM

The theme of the new Museum is Man and Nature in New York State. This requires an integration of science and history whereas the old Museum was devoted strictly to natural science and archeology. Development of the Man and Nature theme is a major departure from the previous and rather simple intention to display the collections. The new intention is to portray concepts and to stimulate the public to appreciate and learn about the world around them. There is no hall of history or hall of science in the new Museum. Instead, three halls depicting the three basic regions of the State will attempt to interpret natural and human interactions within the Adirondack Wilderness, Metropolitan New York City and Long Island, and Upstate New York. The result will be neither a historical museum nor one of natural science, but a museum telling the whole story of New York State, from its primal geologic formation to the emergence of human populations and the changes they wrought on the land. "Chronicles of Change", an award-winning film produced especially for the Museum by Francis Thompson Productions will orient visitors to the Man and Nature theme and will prepare them for entering the regional halls.

In addition to the regional halls, space is allotted for temporary and topical exhibits. For example, a new Bicentennial exhibit will celebrate New York's past and present, and one exhibit, "Birds of New York" will stress identification of birds in their natural habitats. "The World of Gems," an attractive exhibit which attempts to tell the story of gems and show where New York State fits into the gem world, will be transferred from the old Museum. Eventually, plans call for an exhibit on geology of the State.

Within the Cultural Education Center the main exhibition area contains 140,000 square feet (13,000 square meters) of exhibit space, more than five times the amount of space in the old Museum. Most of the exhibit space is allotted to the regional halls but temporary and topical exhibits will occupy about 25,000 square feet (2,325 square meters). There is also space for educational services such as museum classrooms. When the Museum opens on July 1, 1976, the public will view the completed Adirondack Wilderness Hall, portions of the other regional exhibits, the temporary Bicentennial exhibit, and temporary history exhibits. The regional halls for Metropolitan New York City and Upstate will open at some future date.

THE NEW YORK STATE MUSEUM EXHIBITS CENTER

The innovative scope of this new Museum demanded an entirely new approach to exhibit planning and design. This task was assigned to the New York State Museum Exhibits Center. A tour of this center is scheduled for Stop #2.

Here, a staff of exhibit planners, trained in science, history or anthropology provide ideas for exhibits and do the research required to write the exhibit storyline, and select artifacts and specimens for display. The planner's end product is a detailed plan, a "script," somewhat like a scenario for a motion picture, telling the purpose of the exhibit and the form it will take, and listing the graphics and objects to be shown, and including all labels for the exhibit. Once a script is completed, planners and designers cooperate to prepare floor plans and sclae models, in an attempt to transmit what are often abstract notions into three-dimensional form. The result is a kind of blueprint, which is delivered into the hands of the Exhibit Center craftsmen. These men and women transform the ideas of the planners and designers into final exhibit form. Their job is enormous and their skills are many. Model makers, carpenters, silkscreen specialists, taxidermists, graphic artists, filmmakers, photographers and restorers are included on the staff.

THE ADIRONDACK WILDERNESS HALL

At Stop #3 you will tour the as yet unfinished Adirondack Wilderness Hall of the new State Museum. The Hall will be completed for the Museum opening on July 1. In the Adirondacks, nature predominates. Man's presence, though important, is not as apparent among the mountains, lakes, and forests as it is in other areas of the State. Accordingly, the Adirondack Wilderness Hall begins with a description of these basic elements as they existed in the prehistoric wilderness of some 4,000 years ago. Essential to this setting is an exposure to the wilderness community--its biota, including man, its climate, and its geology.

Next, a series of exhibits depicts how the prehistoric wilderness has been altered over the years by human and natural actions and interactions. Illustrating these modifications are exhibits dealing with the Adirondack land surveys, logging, transportation, mining and recreation. The final series of exhibits depicts how the forest appears today.

The theme exhibit for the hall summarizes and re-establishes the idea that the Adirondacks began as a wilderness, were modified, and now are a different type of wilderness. All the exhibits are grouped by topics but not arranged in linear sequence. Visitors do not need to follow a prescribed path through the hall or see each exhibit in order to comprehend the theme. Rather, the entire hall attempts to convey to visitors a sense of the total Adirondack Region through the use of various media and through the juxtaposition of scientific, historic and fine arts objects. A guiding philosophy for the Museum is that if exhibits relate closely to a theme and if artifacts and specimens are well chosen, a sense of quiet enjoyment and painless learning will replace the "museum fatigue" that sometimes discourages visitors in large museums.

GEOLOGIC CONCEPTS PRESENTED IN EXHIBITS FOR
THE ADIRONDACK WILDERNESS HALL

While only two exhibits in the Adirondack Hall deal exclusively with geology, geologic concepts are integral to many of the exhibits. Visitors will not gain functional geologic knowledge, but will acquire increased awareness of New York's geologic environments. The following list summarizes geologic concepts in the Adirondack Wilderness Hall:

Mountains, Forests, and Water constitute the natural environment of the Adirondacks.

The Adirondacks are a mountainous region underlain largely by erosion-resistant rock over 1,000 million years old. A foundation for the State, rocks of similar type and age are buried under younger sedimentary rocks in most of New York.

The present Adirondacks are recent mountains, which are really the base of a former mountain range. Uplift and erosion through geologic time removed the ancient mountains, sculpturing the present Adirondacks. During the last Ice Age, glacial ice modified the Adirondacks only on a minor scale.

The oldest exposed rocks in the State form the Adirondacks. All the major rock types are metamorphic. The High Peaks region consists primarily of 1,500 square miles (3,900 square kilometers) of an unusual rock type--anorthosite.

The lower slopes and valleys of the Adirondacks have a covering of glacial sediment-silt, sand, and boulders-in which vegetation takes root. Only certain plants can survive on the thin soil and bare rock of the higher slopes.

What man does with an area depends on what he knows about its geology, topography, flora and fauna, and water resources.

Maps communicate information about the physical situation of an area.

Early Adirondack surveys pitted man against the harsh yet beautiful mountain environment.

The combination of climate, geology, topography, and vegetation makes the Adirondacks a water-holding reservoir for the rest of the State. Numerous bogs especially help maintain the watershed.

The harshness of the Adirondack topography severely limited transportation within and into the Region until the coming of the railroad. The automobile and paved road have at last made the area reasonably accessible to man. The natural valleys and passes are still the major travel routes--the easiest ways into the mountains.

The Tug Hill Plateau is largely a landscape empty of man. This flat highland has an unfavorable climate, inadeuqate surface drainage, and poor soil.

19th century iron mining had extensive effects on the Adirondack environment. Pig-iron production required large amounts of iron ore, charcoal, and water power. The clear cutting of hillsides for fuel hastened erosion and silting of streams. The production of charcoal resulted in a heavy creosote-laden haze.

In the 19th century only those mines linked by rail to the lowlands were successful. Today, mining still depends upon reliable transportation.

Modern technology enables mining companies to remove a greater variety and quantity of ores, while maintaining tighter control over modification of the wilderness. Metallic ores, industrial minerals, and stone materials which are mined today in the Adirondacks and are on display in the Adirondack Hall:

talc
zinc
garnet
ilmenite
wollastonite
iron

Clear-cutting of the forests for lumber hindered water-holding at higher elevations, and hastened soil erosion and stream silting.

The Forever Wild Amendment is an expression of concern for preservation of the Adirondack Wilderness.

Mountains, rock outcrops, and vegetation can evoke strong emotional responses in those who view them. Paintings, photographs and recreational activities are evidence of response to aestheti aesthetic aspects of the Adirondack environment.

Recreational activities taken as a whole, regardless of their individual merit, do create a situation which endangers the wilderness.

SUGGESTED READING

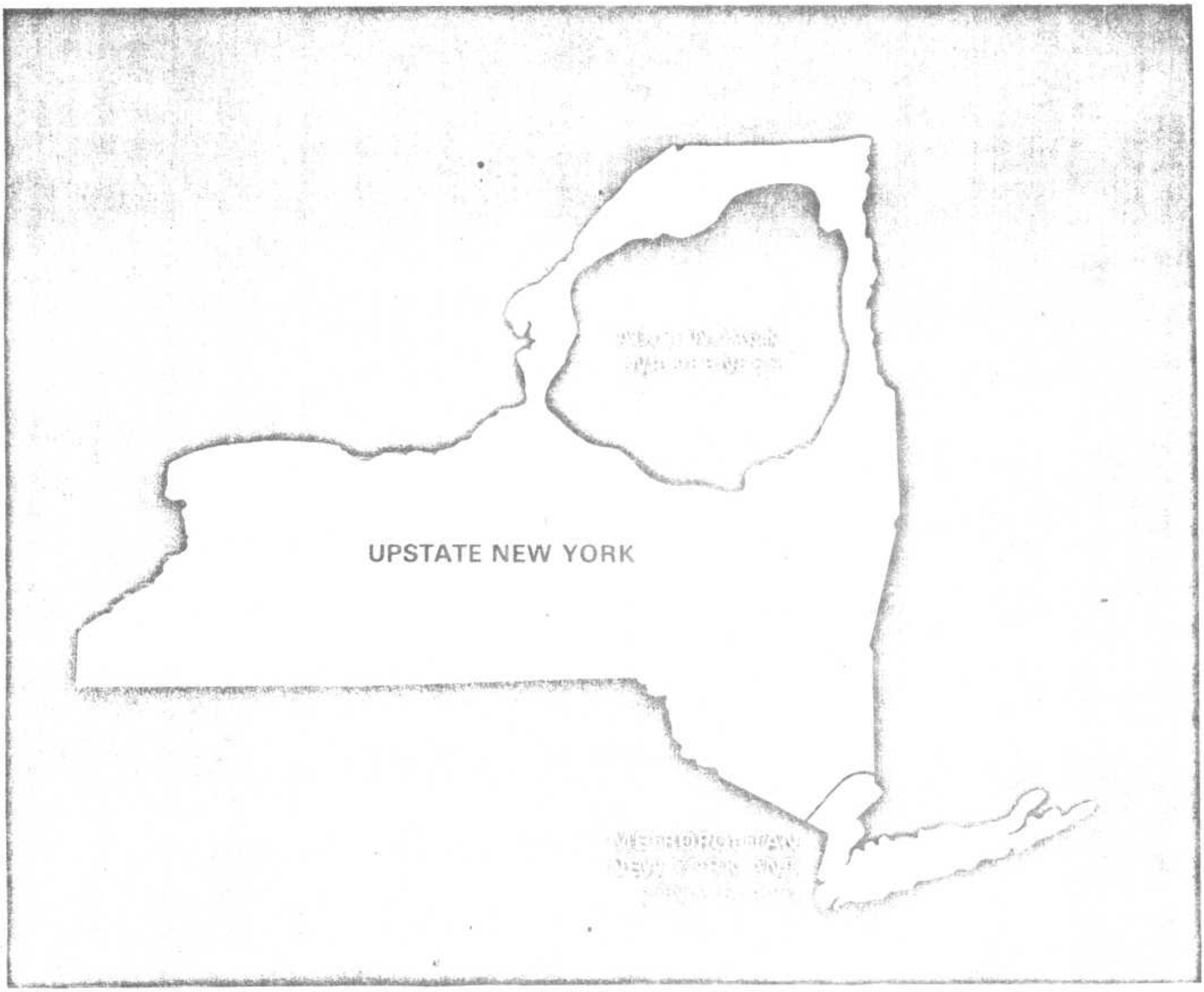
These references provide information on museums and museum work:

American Association of Museums, 1971, Museums and the Environment: A Handbook for Education. Arkville Press, New York, 261 p.

Burcaw, G. Ellis, 1975, Introduction to Museum Work, The American Association for State and Local History, Nashville, Tenn., 202 p.

Williams, Patricia M., 1973, Museums of Natural History and the People Who Work in Them. St. Martins Press, New York, 120 p.

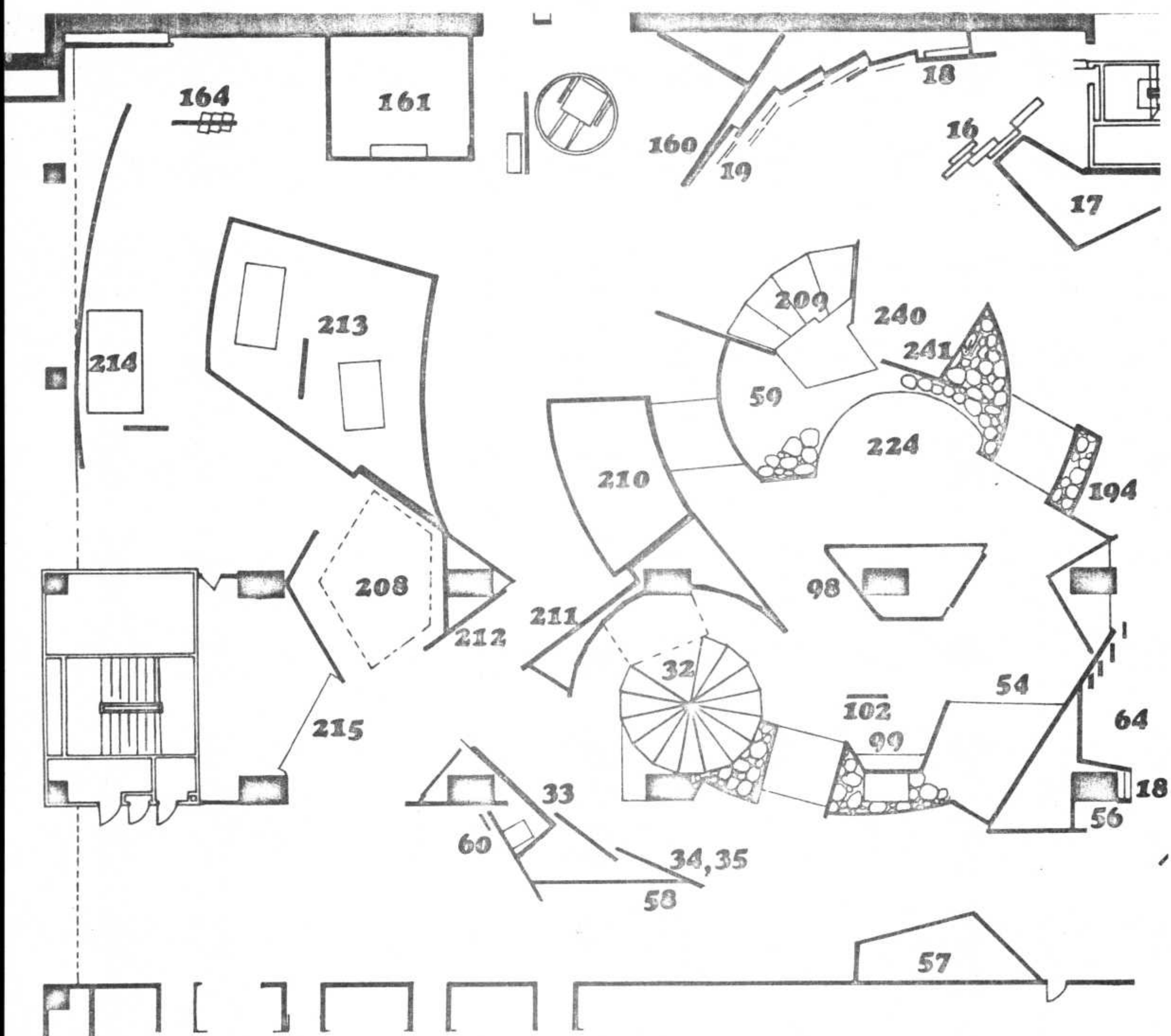
Wittlin, Alma S., 1970, Museums: In Search of a Usable Future. The MIT Press, Cambridge, Massachusetts, 300 p.



1. Adirondack Wilderness -- Approximately 30,000 square feet of space in the new State Museum will contain exhibits about the natural and cultural history of the Adirondack Region. Exhibits will be divided into three basic subdivisions: a) The Prehistory Forest, b) The Modification Complex, c) The Contemporary Wilderness. The Prehistory Forest features a full-size life group of an encounter between an archaic Indian and an elk. The Modification Complex features displays on logging, mining and recreation. The Contemporary Wilderness features a multi-media presentation summarizing the exhibit.

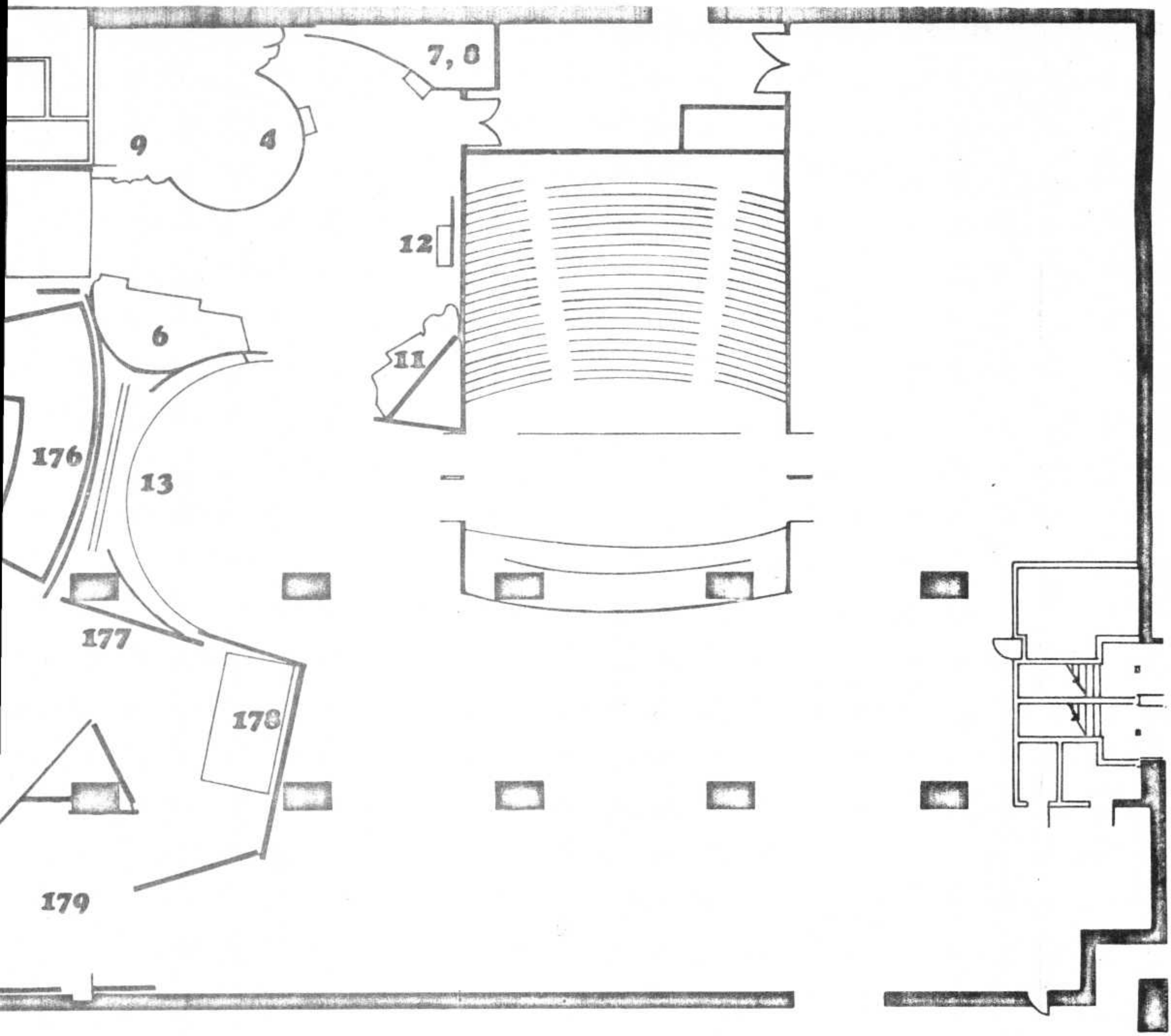
2. Upstate New York -- Still in the planning stages, this 30,000 square feet of exhibit space will present the natural and cultural history of Upstate New York.

3. Metropolitan New York and Long Island -- Approximately 30,000 square feet of space in the new Museum will contain exhibits about the natural and cultural history of Metropolitan New York and Long Island. The exhibit will be organized under four subdivisions: a) Open Spaces, b) Skyscraper City, c) Urban Systems, d) Port. These four subdivisions include exhibits on transportation, housing, communications, immigration, marine environments, social systems, the garment district, power and energy, climate and landscape.



Adirondack Floorplan

4 Man the Hunter, Elk the Game
6 Timber Wolf Family
7 Mountain Lion
8 Canada Lynx
9 Wolverine
11 The Adirondack Mountains Have Not Always Existed as We See Them Now.
12 The Prehistoric Wilderness: 4,000 Years Ago in the Adirondacks
13 The Adirondack Region Mountains Forest Water
16 Adirondack Land Surveys
17 Colvin Signal Tower
18 Adirondack Cartography
19 Survey Adventures
32 The Forest Living Dying Changing
33 Forest Fire - A Powerful Force For Environmental Change.
34 35 Insect and Fungus Damage
53 White Pine Blister Rust
54 The Black Bear
56 Forest Tent Caterpillar
57 A Time of Change for Deer and Forest
58 Beavers and Men
59 Eliminated Mammals
60 The Endangered Ones
64 Adirondack Waters



98 Adirondack Weather
99 Adirondack Bogs
102 Bogs Are Clues to Climates of the Past
160 Mining and Transportation
161 Early Mining in the Adirondacks
164 Mining Today
176 Log Jam on the Upper Hudson
177 Clearing the Forest
178 Banking Grounds and Bunkhouse Life
179 Mill Town - The Destination of Logs and Loggers
180 White Pine Weevil
194 New Yorkers Preserve the Wilderness
208 When Men and Mountains Meet
209 The Observant Traveller Sees Mountains - and More!
210 Wilderness Camping
211 The Impatient Angler
212 Adirondack Seasons Four + One
213 The Adirondack Sojourn - Then and Now
214 The Wilderness Cure
215 The Paradox of Wilderness Recreation
240 Mountain Travel - 20 Will Get You 10 (Miles)
241 The Tug Hill Plateau - The Returning Wilderness
224 Adirondack Wilderness

TRIP C

DEVONIAN ALLUVIAL AND TIDAL LITHOFACIES

BETWEEN

PALENVILLE AND GILBOA, NEW YORK

by

Kenneth G. Johnson
Skidmore College

INTRODUCTION

One of the greatest thicknesses of Devonian rocks on the North American continent is at the northeastern end of the Allegheny Synclinorium in east-central Pennsylvania and southeastern New York. The sequence crops out along a north-facing escarpment extending from Lake Erie to the Catskill Mountains, a distance of some 300 miles. The escarpment continues south along the west side of the Hudson Valley into the Valley and Ridge physiographic province of the Appalachian highlands. The New York sequence is accepted as the standard for the Devonian System of North America. In the Catskills, although the top has been eroded, the Devonian is some 10,000 feet thick. It thins to about 2500 feet at the western edge of New York State and also thins toward the southwest. In northeastern New York Devonian rocks have been removed by erosion. In New York State the Devonian sequence was only slightly affected by the Appalachian Revolution; it was deformed into gently undulant folds. More intense tectonic forces to the southwest in Pennsylvania folded the same strata into elongate, plunging anticlines and synclines.

The upper Middle Devonian and Upper Devonian of eastern New York and Pennsylvania consist of a thick wedge of continental rocks that have a progradational relationship to marine formations farther west. These rocks have a deltaic character.

The deltaic wedge is composed of detritus derived from a source area east of the present-day Catskill Mountains which was being elevated by the first pulses of the Acadian Orogeny. At the base of the clastics is an interval of some 2500 feet of fossiliferous sandstones and shales (Hamilton Group) which thins toward the west and southwest. Penetrating eastward from the marine basin into the upper Hamilton clastics are two thin fossiliferous limestone beds (Centerfield and Portland Point) which were deposited during the time that the source terrain was in the beginning stages of uplift. The Tully Limestone, a transgressive carbonate tongue at the base of the Upper Devonian, represents the last significant limestone deposition in the New York Devonian prior to the overwhelming of the marine basin by clastic influx.

After deposition of the Tully, uplift apparently accelerated and continued on a large scale into the Mississippian. A thick wedge of clastic continental sediment (Catskill lithofacies) was deposited at the margin of the basin. The red and green-gray sandstones, shales and conglomerates of this wedge interfinger westward with littoral and shallow marine (Chemung lithofacies) sandstones and shales. These grade into dark-colored shales and siltstones

(Portage lithofacies) farther west that are of deeper marine origin. The irregular, interfingering contact between the continental beds and the marine formations rises stratigraphically towards the west and the continental beds consequently have the appearance of over-riding the marine strata. This prograding relationship, the result of displacement of the late Devonian sea by the expanding clastic wedge, is shown in the cross-section along the N.Y. - Pa. border (Fig. C-1). Dunbar and Rodgers (1957, p. 137-140) give a concise description of the New York Middle and Upper Devonian from the point of view of the facies concept. A correlation chart by Rickard (1964) shows the relationship of the depositional phases of the Devonian rocks in New York State.

Within the Tully Limestone and its eastern clastic correlatives are rocks that are representative of the spectrum of sedimentary environments that comprised the Catskill deltaic system during early Late Devonian Time. These were studied in order to develop associations of criteria that will permit recognition of sedimentary environment elsewhere in the Catskill complex.

GENERAL STRATIGRAPHY
TULLY LIMESTONE AND EASTERN CLASTIC CORRELATIVES

Tully Limestone

The name Tully Limestone was applied by Vanuxem (1838) to a series of beds which are well exposed in central New York in the vicinity of the village of Tully. The Tully, composed mostly of gray calcilutite with subordinate biocalcarenite, constitutes an excellent stratigraphic marker which varies in thickness from 3 to 48 feet in central New York.

The Tully is subdivided, from the oldest to youngest, into the Tinkers Falls, Apulia, and West Brook members (Cooper and Williams, 1935). The guide fossil Hypothyridina venustula characterizes the Apulia Member and the fimbriata biozone is included in the West Brook Member. Both of these zones, which extend into the western part of the Tully clastic correlatives, provide stratigraphic control which was essential for study of the pattern of depositional facies. As defined by Trainer (1932, p. 8), the Tully includes all beds between the Geneseo Shale and the uppermost shale in the Moscow Formation. The Tully interval thickens eastward but the limestone beds become thinner, and east of the Chenango Valley are replaced by terrigenous rocks (New Lisbon and Laurens) (Fig. C-2).

Tully Eastern Correlatives

East of the Chenango Valley, where the limestone grades into very fine-grained clastic strata, the Tully interval is subdivided on a biostratigraphic basis into the New Lisbon (Cooper and Williams, 1935, p. 809) and Laurens (Cooper, 1934, p. 5) "Members" (Fig. C-2). Farther east in the clastic wedge, suitable biologic elements for stratigraphic subdivision are lacking, and that portion of the Tully interval in this region is included in the lower part of the Gilboa Formation (Cooper and Williams, 1935, p. 818). The Gilboa Formation interfingers eastward with strata of the Catskill lithofacies. Correlation farther east within the Catskill lithofacies is equivocal.

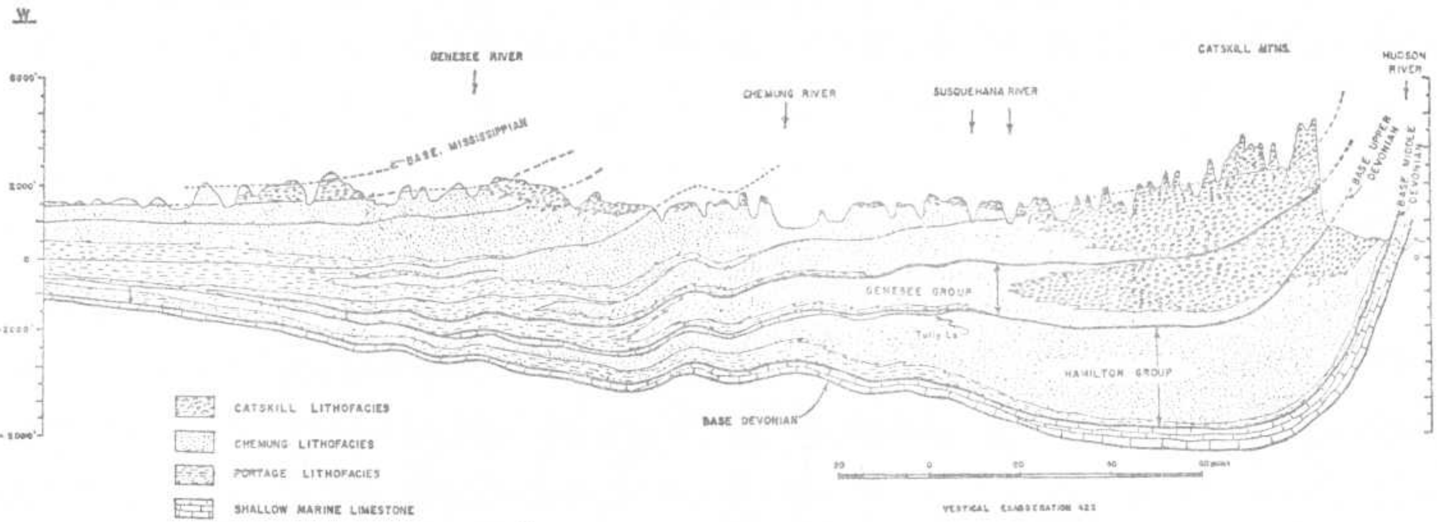


Fig. C-1. Cross-section of Devonian System Along New York - Pennsylvania Border (After Broughton, et al, 1966)

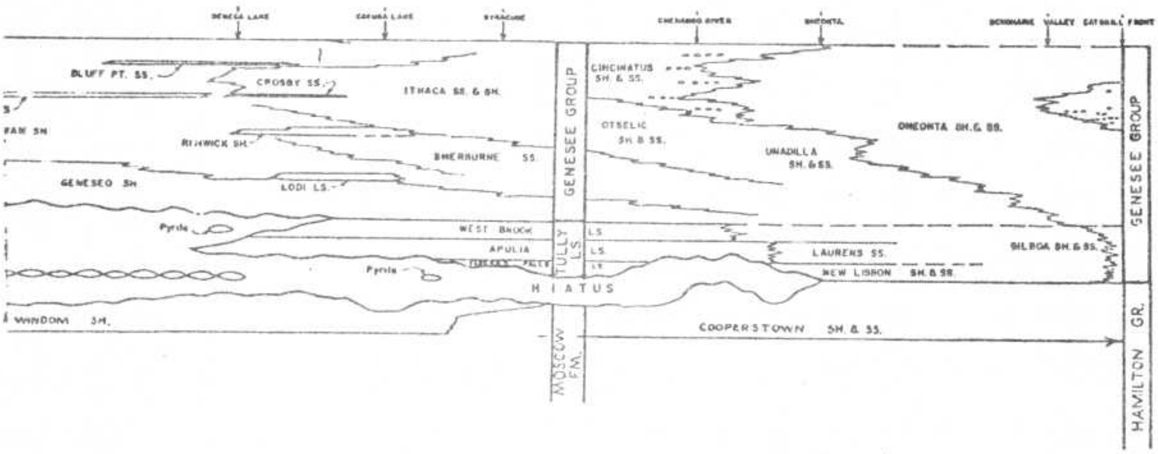


Fig. C-2. Correlation within Genesee Group, basal Upper Devonian, New York State (after Rickard, 1964).

LITHOSOMES
TULLY AND ASSOCIATED STRATA

The Tully Limestone and associated strata are subdivided into four lithosomes (Fig. C-3). Lithosome A is the thinned eastward extension into the study area of the Tully Limestone. The unit consists of argillaceous calcilutite and sandy biocalcarenite. Lithosome B, which lies directly above Lithosome A and is co-extensive with the tongue shaped eastern extension of the Geneseo Shale, consists of very dark fissile shale grading eastward into shaly siltstone. Lithosome C forms a massive clastic wedge which in cross-sectional view envelops Lithosomes A and B. It is comprised of interlensing gray siltstone and slightly lighter gray, very fine-grained sandstone which contains flow-rolls, trace fossils, coquinite lenses and, at the eastern margin of the lithosome, fossil seed-ferns. Lithosome D consists of red and green siltstone and mudstone with interbeds of gray, fine to medium-grained, texturally very immature sandstone. This field trip focuses on strata of Lithosome D and the easternmost part of Lithosome C.

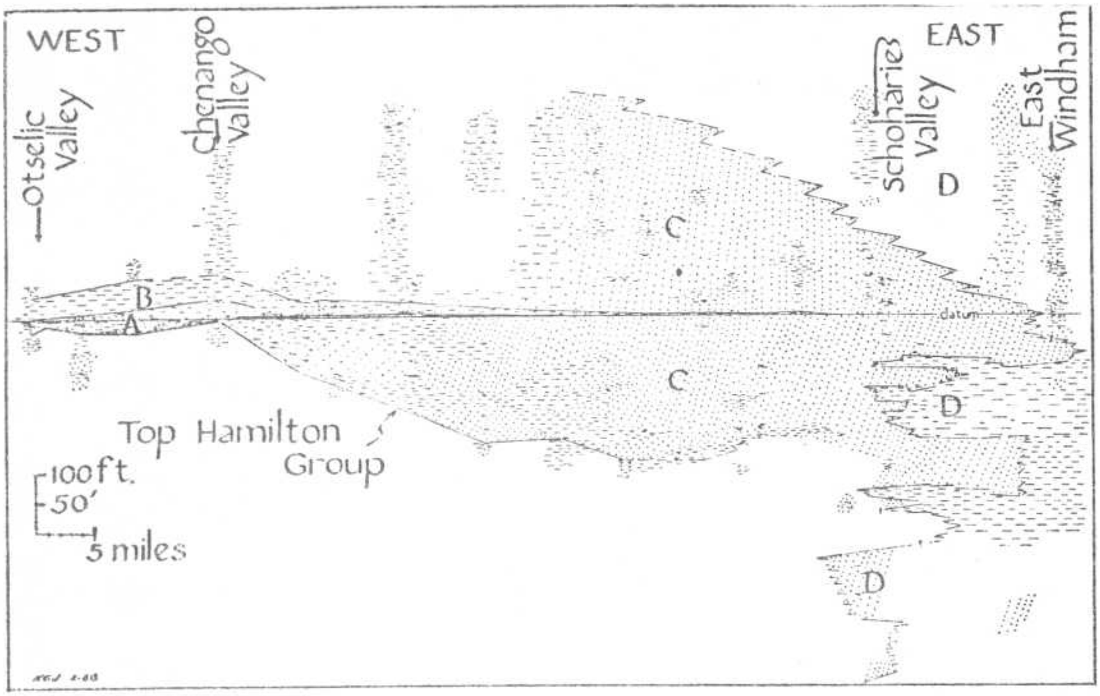


Fig. C-3. Cross-section, Lithosomes in Tully Clastic Correlatives

SEDIMENTARY FACIES OF TULLY INTERVAL

The environmental spectrum of the Tully interval includes alluvial plain, tidal and sub-tidal facies each of which can be further subdivided on the basis of multiple recognition criteria such as sedimentary structures, lithology, geometric relationships of rock units and character of biologic content. Rocks of alluvial derivation are well exposed in the eastern part of the study area. Sandstone bodies of alluvial channel origin truncate underlying beds, contain basal shale-pebble lag-concentrates, are well cross-bedded, are texturally very immature and invariably display a "fining-upwards". The alluvial strata of overbank origin are horizontally laminated, red and green siltstones which locally include large very highly organic lenses and beds representing a marsh environment. At the distal margin of the alluvial plain, just below the Tully interval, a swamp environment is represented at the three levels of the Gilboa seedferns.

Sedimentation that resulted in strata of tidal origin within the Tully interval was of the Wadden-type. The tidal flat facies consists of gray, very finely cross-laminated muddy siltstone and very fine-grained sandstone, which contain allochthonous brachiopods and locally well-developed mud-cracks. Sedimentary structures of the tidal channel facies are essentially identical to those of the alluvial channel facies, but can be distinguished by the unique character of the basal lag-concentrate, which contains very abundant allochthonous brachiopod shells.

Within the strata of sub-tidal derivation a nearshore, predominantly sandstone, facies and an offshore, predominantly siltstone, facies are recognized. Well developed trends of change in texture, general biologic character and type and scale of sedimentary and biologic structures are present in the sub-tidal strata.

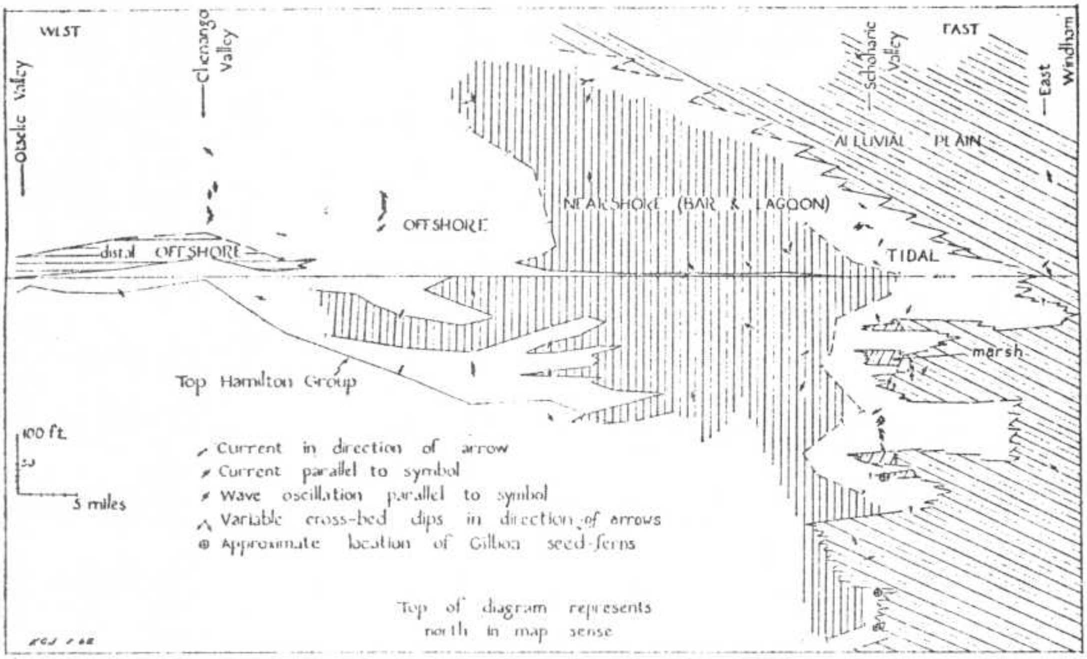


Fig. C-4. Cross-section, Sedimentary Facies in Tully Clastic Correlatives

The purpose of this trip is to study the physical and organic criteria which permit differentiation of those rocks of alluvial origin from those of tidal origin within the Catskill depositional system.

SELECTED REFERENCES

Broughton, J. G., Fisher, D. W., Isachsen, Y. W., and Rickard, L.V., 1962, The geology of New York State (text): New York Museum and Science Service Map and Chart Ser. no. 5.

Cooper, G. A., 1934, Stratigraphy of the Hamilton Group of eastern New York, Part II: Am. Jour. Sci., 5th ser., v. 27, p. 1-12.

Cooper, G. A. and Williams, J. S., 1935, Tully Formation of New York: Geol. Soc. America Bull., v. 46, p. 781-868.

Dunbar, C. O. and Rodgers, John, 1957, Principles of Stratigraphy: New York, John Wiley and Sons, 356 p.

Friedman, G. M. and Johnson, K. G., 1966, The Devonian Catskill deltaic complex of New York, type example of a "tectonic delta complex": in Shirley, M. L., ed., Deltas in their geologic framework, Houston Geol. Society, p. 171-188.

Heckel, P. H., 1966, Stratigraphy, petrography, and depositional environment of the Tully Limestone (Devonian) in New York State and adjacent region: Ph.D. Thesis, Rice University, 256 p.

Johnson, K. G., 1967, Basal Upper Devonian alluvial and infralittoral paleoenvironments in east central New York State (abs.): Geol. Soc. America, Abstracts for 1967, Special Paper No. 115, p. 110.

__________ 1968, The Tully clastic correlatives (Upper Devonian) of New York State: model for recognition of alluvial, dune (?), tidal, nearshore (bar and lagoon) and offshore sedimentary environments in a tectonic delta complex: Ph.D. dissertation, Rensselaer Polytechnic Institute, Troy, N.Y., 122 p. + appendixes and plates.

Johnson, K. G. and Friedman, G. M., 1966, Depositional environments of Tully Limestone and clastic equivalents (Upper Devonian), east-central New York State (abs.): Geol. Soc. America, Abstracts for 1966, Special Paper No. 101, p. 263-264.

__________ 1969, The Tully clastic correlatives (Upper Devonian) of New York State: a model for recognition of alluvial, dune (?), tidal, nearshore (bar and lagoon), and offshore sedimentary environments in a tectonic delta complex: Jour. Sedimentary Petrology, v. 39; p. 451-485.

Johnson, Kenneth G., 1970, Transitional sedimentary facies of the Catskill deltaic system in eastern New York State: in Heaslip, W. G., ed., Field trip guidebook, 42nd Annual Meeting (Cortland), New York State Geological Association, p. C-1 through C-14.

Johnson, Kenneth G., 1972, Evidence for tidal origin of Late Devonian clastics in eastern New York State, U.S.A., Proceedings, Section 6, Stratigraphy and Sedimentology, 24th International Geological Congress, Montreal, p. 285-293.

Rickard, L. V., 1964, Correlation of the Devonian rocks in New York State: New York State Museum and Science Service Map and Chart Ser. no. 4.

Trainer, D. W., 1932, The Tully Limestone of central New York: New York State Museum Bull. 291, 43 p.

Vanuxem, Lardner, 1838, Third Annual Report of the Third Geological District of New York: Assembly Document 275, p. 278.

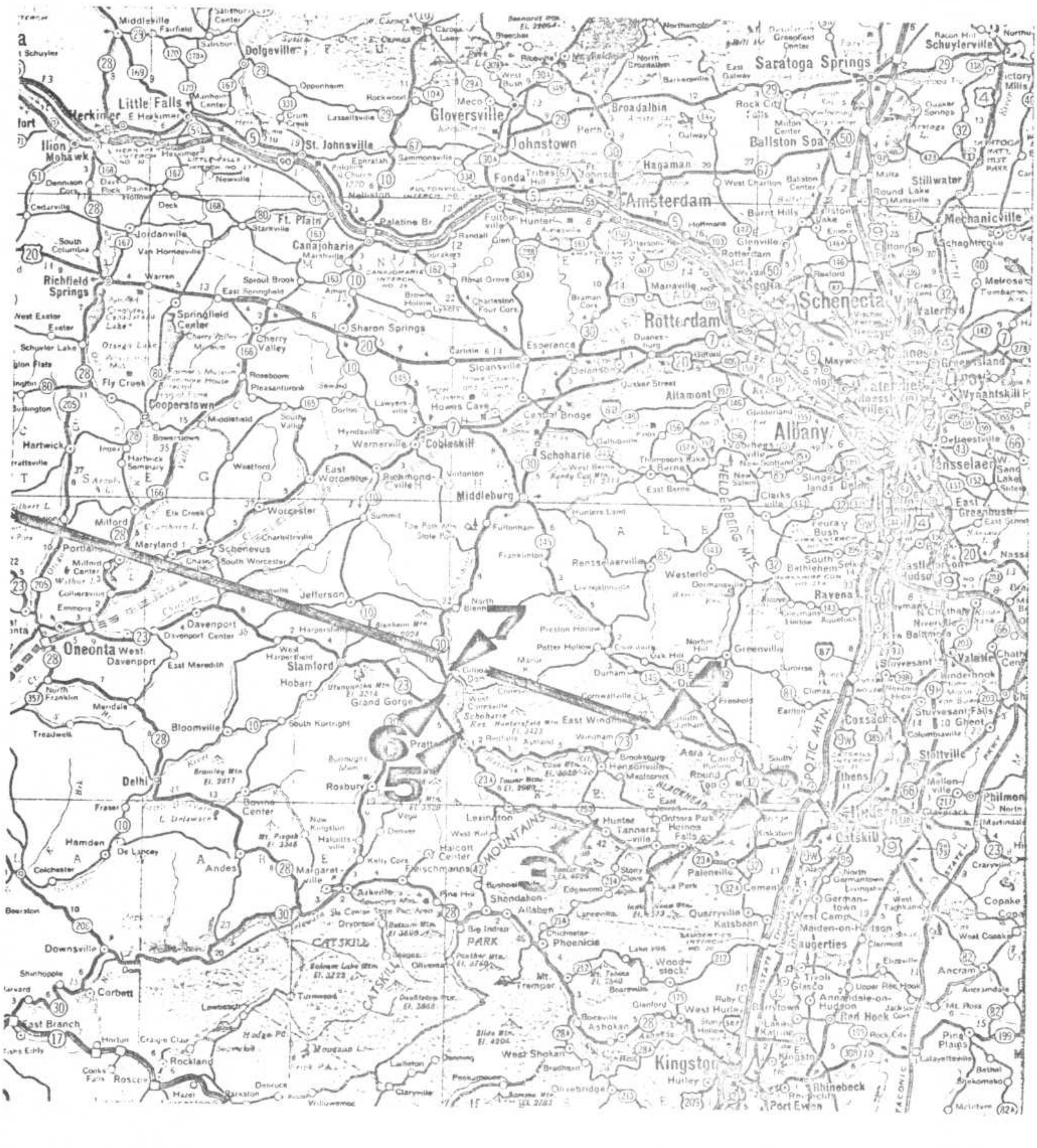


Fig. C-5. Numbers indicate field trip stops. Heavy line is easternmost part of line of section for Figs. C-3 and C-4.

ROAD LOG

Cumulative distance (From Interstate Rt. 87 Clifton Park Exit)	
	Leave parking lot on south side of Case College Center, Skidmore College. Proceed to Interstate Rt. 87 and drive south.
	Clifton Park exit from Interstate Rt. 87. Continue south on Rt. 87.
5.1	Crossing Mohawk River. River is incising into Middle Ordovician Normanskill graywacke and shale.
5.6	Outcrop on left - Normanskill dipping steeply east.
6.6	Sand pits on right in wind reworked sand of glacial Lake Albany.
7.9	Exit 6 - Latham.
13.2	State University of New York - Albany on left. Passing through area of stabilized sand dunes composed of Lake Albany Pleistocene sand.
13.7	Leave Interstate 87 NEW YORK STATE THRUWAY toll gate. Proceed south on Thruway.
21.1	Normans Kill at southern outskirts of Albany.
24.1	On right - Helderberg Escarpment (Lower Devonian limestones) in distance.
26.8	On right - outcrop of Normanskill Formation.
28.4	MASSACHUSETTS TURNPIKE EXIT (21A). Continue south on Thruway.
30.8	On right - Atlantic Cement Company plant. This modern, automated facility utilizes Helderbergian (Lower Devonian) limestone.

Cumulative distance (From Interstate Rt. 87 Clifton Park Exit)	
33.6	On left - outcrop of Normanskill Formation.
35.6	Thruway rest area - gas, food and rest rooms.
37.0	On right - low escarpment of Helderbergian limestone.
41.4	On left - view of Hudson Valley.
42.1	Vertically dipping beds.
46.8	Vertically dipping Helderbergian limestone.
49.0	LEAVE THRUWAY AT EXIT 21 (Catskill).
49.6	On right - Catskill Front in distance. This impressive topographic feature marks the northeastern margin of the Allegheny Plateau. It is composed of Middle and Upper Devonian clastic strata.
49.7	TOLL GATE, EXIT 21.
	TURN EAST ON ROUTE 23.
51.4	Catskill village limits.
51.6	Bear right - take Rt. 23A (WEST).
51.8	Cross Kaaterskill Creek.
53.1	Outskirts of Catskill. Proceed west on Rt. 23A.
53.4	Outcrop of Helderbergian limestone - dip nearly vertical.
53.8	Straight ahead - Catskill Front in distance.
55.1	Contorted bedding in Lower Devonian beds.
55.5	Cross over THRUWAY. Exposure of Onondaga Limestone with chert nodules.

Cumulative distance (From Interstate Rt. 87 Clifton Park Exit)	
56.0	Cross stream and climb fluvial terraces.
	Outcrops are Hamilton Group (lower Middle Devonian) clastics.
59.0	Kaaterskill Flat. Note red soil coloration. In distance ahead is Kaaterskill Clove.
59.4	Junction Rts. 23A and 32. Continue west on Rt. 23A.
	Outcrops seen during remainder of climb up Catskill Front will be red, overbank shales and siltstones interbedded with gray, cross-bedded fluvial channel sandstones of the Catskill Lithofacies.
60.6	Note sandstone ledges on Catskill Front.
61.7	Traffic light in PALENVILLE.
62.0	On left - chapel constructed of boulders, the lithologies of which are representative of the eastern part of the Catskill Lithofacies.
62.7	Cross Kaaters Kill. A short distance downstream (out of view) are large, well-developed potholes.
63.7	Road swings sharply to left. Here it is possible to look across the narrow Kaaters Kill gorge at the interbedded red shales and gray sandstones of the Catskill Lithofacies.
65.2	Road swings sharply to left. Cascade on right formed where tributary of Kaaters Kill flows over sandstone ledges.

Cumulative distance
(From Interstate Rt.
87 Clifton Park Exit)

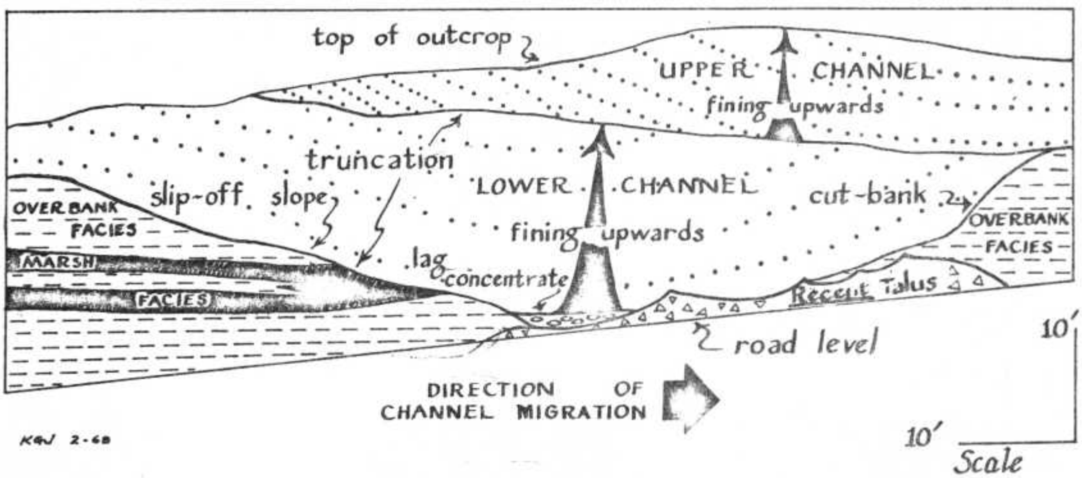
65.4	STOP 1 · Pull off on overlook at left side of road. From this point it is possible to look east down Kaaterskill Clove. The cross-sectional profile is typical of high-gradient streams that are engaged in active vertical erosion. The Kaaters Kill is considered to be an excellent example of a short, high-gradient stream that has managed to capture the headwaters of a longer lower-gradient stream flowing in an opposite direction. The elbow of capture is at Haines Falls, just west of this observation point.
	CONTINUE WEST UP THE CLOVE ON RT. 23A.
66.5	Haines Falls village limits.
66.8	Turn right and proceed to North Lake Public Campsite.
69.1	On right - Scutt Road.
69.7	Entrance - North Lake Public Campsite. Enter and take first left. Proceed to bath house on east side of North Lake. Drive just beyond bath house and turn into open area.
71.1	STOP 2 - Park and continue on foot up path to former site of Catskill Mountain House. From this vantage point one is provided an excellent view of the Hudson Valley, providing weather conditions are suitable.
	LEAVE NORTH LAKE PUBLIC CAMPSITE and return to Rt. 23A at Haines Falls.
75.4	Turn right on Rt. 23A and proceed west.
76.9	Tannersville village limits.
78.7	Note flat tops of mountains. The Catskills are erosional mountains (in contrast to fold, block-faulted or igneous types) that have resulted from stream dissection of the generally flat-lying strata of the Allegheny Plateau.

Cumulative distance
(From Interstate Rt.
87 Clifton Park Exit)

81.2	Hunter village limits. Proceed through Hunter.
83.0	Junction Rts. 23A and 296. Turn right on Rt. 296 and park.
	STOP 3 - Exposure of cobble conglomerate at base of one of fluvial channels in Catskill Lithofacies. This basal lag concentrate was apparently deposited quite near a high source area and is assigned to the inland flood-plain facies.
84.7	On right - gravel pit in Pleistocene glacio-fluviatile deposits.
85.3	Cross-bedded sandstone of the alluvial channel facies.
89.3	Hensonville village limits.
90.6	Junction Rts. 296 and 23. Turn right on Rt. 23. Proceed east.
93.1	On right - alluvial channel sandstone and overbank shale. Note irregular erosion surface at base of channel.
96.2	On right - East Windham Post Office. To left (northeast), in distance, dip slope of Helderbergian (Lower Devonian) strata.
	Proceeding down northeast - facing escarpment consisting of Middle and Upper Devonian clastic strata, mostly of continental origin. The escarpment farther north and northeast consists of Lower Devonian (Helderbergian) limestone units of shallow marine origin. Strata in the section between East Windham and Durso Corner to east are almost entirely alluvial channel sandstones and interbedded overbank shales and siltstones.
97.3	On right - high on outcrop is tan sandstone (much lighter in color than sandstone in remainder of o/c) assigned to tidal channel facies.

Cumulative distance
(From Interstate Rt.
87 Clifton Park Exit)

97.8 — STOP 4 - Driveway on right (to Randazzo house). Park at roadside. A short distance downhill is a compound alluvial channel and laterally equivalent overbank siltstones. At the driveway are overbank facies root stigmaria and a highly calcareous overbank "evaporite" bed.



(Johnson, 1968)

RETURN TO JUNCTION RTS. 296 and 23 and continue west on Rt. 23.

104.5	Junction Rts. 296 and 23.
104.8	On left - river terraces.
106.9	On left - glacial deposits across valley.
110.3	Ashland village limits.
111.6	Sharp river bend, cut bank, bar development.
115.0	On right - exposures of Catskill Lithofacies.
115.2	Junction Rts. 23 and 23A. Turn right and proceed west on Rt. 23.

Cumulative distance
(From Interstate Rt.
87 Clifton Park Exit)

116.4	Prattsville village limits. Pratt Rock on right.
117.3	Cross south end of Schoharie Reservoir.
118.6	On right - Hummocky glacial deposits.
119.0	AT POWER SUBSTATION - turn right on unsurfaced road.
119.4	STOP 5 · Hardenburg Falls. At this point Bear Kill flows into Schoharie Reservoir. Beds here are assigned to the tidal channel and tidal flat facies. The tidal channel facies is represented by gray, cross-bedded, fossiliferous sandstones and the tidal flat facies by very dark gray, very thin-bedded, in part conglomeratic, shales. Lag-concentrates in both facies are rich in shallow marine brachiopod shells.
	RETURN TO ROUTE 23.
119.7	Route 23 - turn right and proceed west on Rt. 23.
122.3	Grand Gorge village outskirts.
122.7	At traffic light in Grand Gorge turn right onto Rt. 30 and proceed north.
124.3	Top of section consisting of alluvial channel sandstones and overbank shales.
	Continue north on Rt. 30 (down hill).
124.8	Pull off on left side of road.
	STOP 6 - On east side of road exposure of gray, cross-bedded sandstone of tidal channel facies with lag-concentrates of shallow marine spiriferid brachiopods.
	CONTINUE NORTH ON RT. 30

Cumulative distance
(From Interstate Rt.
87 Clifton Park Exit)

125.1	On right, in distance - large quarry from which much of stone for Gilboa Dam was taken. Completion of dam impounded waters of Schoharie Creek, forming Schoharie Reservoir; a part of New York City water supply system.
125.7	Turn right on road to Gilboa.
126.1	View north down Schoharie Valley. Note even crest of hills flanking valley, a result of stream dissection of nearly horizontal Devonian strata.
126.9	Gilboa Bridge across Schoharie Creek. Park on right at west end of bridge.
	STOP 7 - Display of seed-fern stumps taken from quarry just to southwest. Some 200 specimens were found during the quarrying operation. These seed-ferns are thought to have grown to heights of some 60 feet in swamps along the seaward margin of the Catskill alluvial plain during late Medial Devonian time. They were buried during a minor oscillation of the marine shoreline in tidal channel or bar sand deposits.
	Proceed north along west side of Schoharie Creek on Stryker Road (County Rt. 13).
128.3	Ledges on west bank of Schoharie Creek - Hamilton Group sandstones with well-developed burrow structures.
128.5	TURN LEFT ON UNSURFACED ROAD - climb hill.
129.1	On left - road leading into abandoned BORNT HILL QUARRY.
129.5	Route 30 - turn right and proceed north on Rt. 30.

Cumulative distance (From Interstate Rt. 87 Clifton Park Exit)	
130.7	CROSS MINE KILL - Mine Kill Falls on right (excellent upper Hamilton Group Section).
134.0	North Blenheim village outskirts.
135.0	Bridge across Schoharie Creek. On right - World's longest single-span covered wooden bridge.
139.2	Breakabeen village limits.
140.2	On right, across valley - exposures of Panther Mountain Formation (middle Hamilton Group).
140.4	Cross Schoharie Creek - good swimming hole on right.
140.9	Junction Rt. 30 and County Rt. 4 (West Fulton Rd.).
142.6	Fultonham
143.0	Up valley in distance - Vrooman's Nose, composed of Hamilton Group shales and sandstones.
143.6	Watsonville
145.2	On right - one of few remaining octagonal houses in New York State.
147.0	Cross Schoharie Creek and enter Middleburg. Bear left and remain on Rt. 30.
149.6	On right - rock quarry in Onondaga limestone.
150.8	Enter Schoharie. Road "drops" over ledge of Upper Silurian Cobleskill Limestone.
152.1	On right - rock quarry in Cobleskill Limestone.
152.4	On left - Onondaga Limestone exposed high on hillside.

152.7	On right - Old Stone Fort constructed during Colonial period.
154.3	Remain on Rt. 30.
155.7	Junction Rts. 30 and 7. PROCEED EAST ON RT. 7.
163.4	Junction Rts. 7 and 20 in Duanesburg. CONTINUE ON RT. 7 through Rotterdam to Schenectady and Junction of Rts. 7 and 146.
approx. 179.5	Junction Rts. 7 and 146. Turn left on Rt. 146 (Balltown Road).
approx. 183.4	Cross Rexford Bridge - on right post - Pleistocene gorge of Mohawk River incised in sandstones and shales of Schenectady Formation. Prior to formation of this gorge ancestral Mohawk reached Hudson River via valleys occupied by present Alplas Kill, Ballston Lake, Ballston Creek, Round Lake and Anthony Kill and flowed into the Hudson River at Mechanicville.
approx. 184.5	Route 146 swings east. Continue straight ahead on Blue Barn Road.
approx. 187.2	Gulf station on left. Entering Kingsley Road. Bear right.
approx. 187.8	Route NY 50. Turn right (north).
	Continue north on Rt. 50, through Ballston Spa, to Saratoga Springs.

End Road Log

TRIP D

MINERALS AND MINING

by

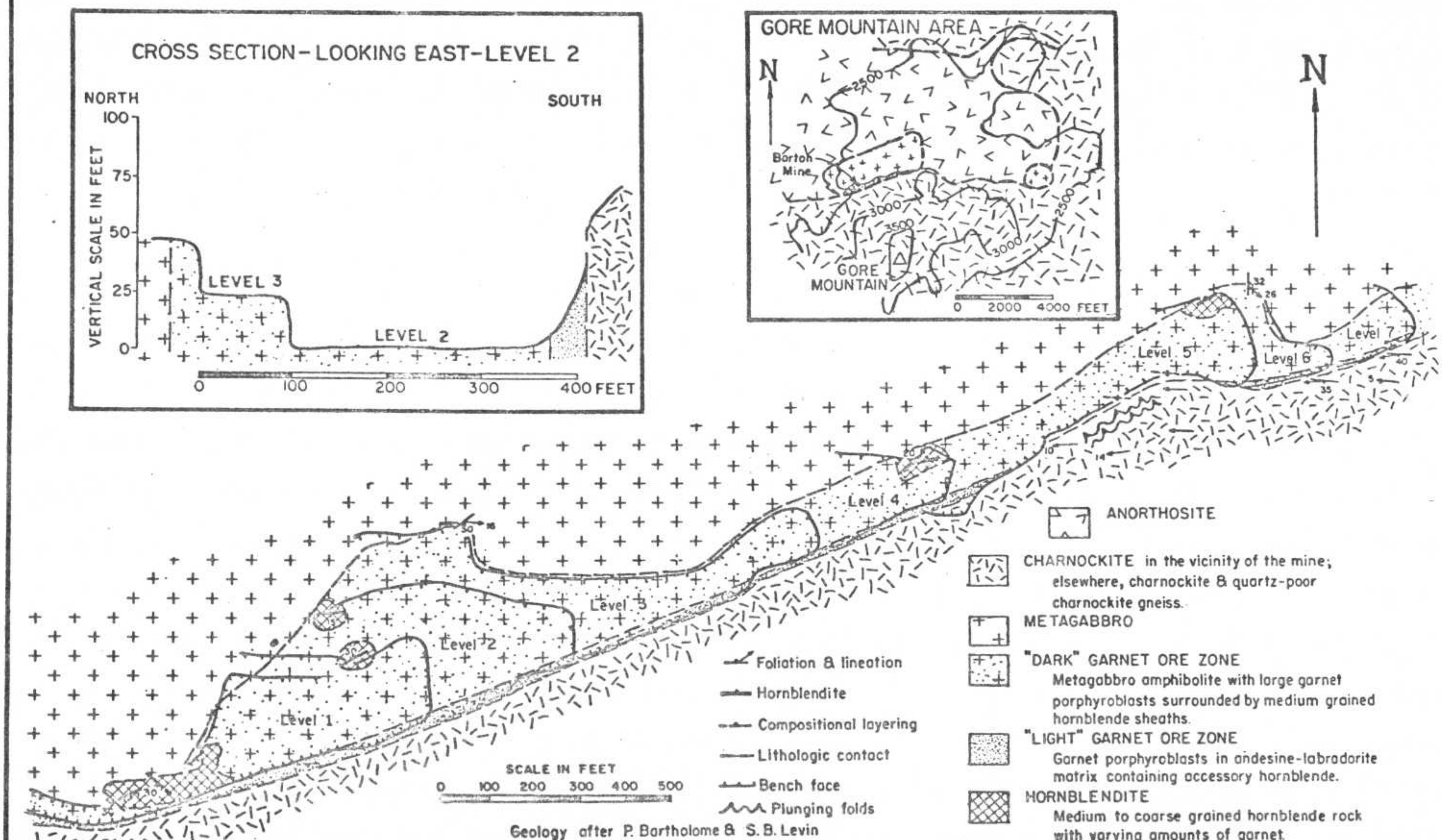
John J. Thomas
Skidmore College

(Much of the material for this trip is taken from or adapted from Field Guide to the Central Portion of the Southern Adirondacks, J. F. Davis, Educational Leaflet Series, No. 12, The State Education Department, State Museum and Science Service, Albany, 1962.)

0.0	Starting mileage of the field trip is Case College Center parking lot Skidmore College. Proceed out through main gate and turn right (south) on Broadway.
0.8	Left on East Avenue.
1.2	Left (east) on routes U.S. 9 and N.Y. 50. Follow N.Y. 50 to the Northway I 87.
2.4	Left (north) on the Northway I 87.
14.3	Butler Road bridge.
	From this point you can observe the general shape of the Adirondack Dome. From right to left the dome rises out of the surrounding Paleozoic rocks. There are two easily seen breaks in the dome-like profile, both of these are graben. The second from the right is occupied by Lake George. The Lake George graben is a north-northeast trending down-dropped block of Cambrian and Ordovician sedimentary rock surrounded by Precambrian blocks of the charnockitic and granitic gneiss suites.
24.5	Lake George Exit (continue on Northway).
	The City of Lake George is famous not only as a tourist area, but also historically. Near it is located the site of the Bloody Pond skirmish, a minor battle of the French and Indian War. The battle was won by the British and they disposed of their dead foes in the pond. Also, the city contains a restoration of Fort William Henry built by Sir William Johnson in 1755-56. General Montcalm surrounded the fort in 1757 and laid seige to it. He insured the defenders free passage, but the unprepared British were massacred by the uncontrollable Indians.

GEOLOGY OF BARTON GARNET DEPOSIT

North Creek, New York



(From J. F. Davis, The State Education Department, 1962.)

I. Structural Geology of the Gore Mountain Area: Charnockite foliation is subhorizontal in the area adjacent to anorthosite. Elsewhere, charnockite foliation defines several open folds. The anorthosite associated with the Barton mine metagabbro is a sheet-like body overlain and underlain by charnockite. The metagabbro-anorthosite contact is very steep. The charnockite-metagabbro contact is almost vertical.

II. Description of Lithologies:

A. Charnockite: green gneiss; microperthite with minor quartz, hornblende, pyroxene, plagioclase; rarely garnet.

B. Anorthosite: coarse plagioclase gneiss with subordinate hornblende, pyroxene, garnet; displays what some have interpreted as remnant ophitic texture.

C. Metagabbro: rock of the central portion of the metagabbro body has remnant ophitic texture. In the "dark ore zone," along the southern margin of the body, metagabbro has been transformed to a porphyroblastic garnet amphibolite. A continuous textural and mineralogical transition exists between the least modified central phase and rock of the "dark ore zone."

1. Least Modified Metagabbro: primary inclusion-bearing augite and labradorite (crystals up to 15 mm); remnant ophitic texture; olivine crystals in augite; fine-grained xenoblastic garnet and hornblende are developed along contacts of plagioclase and augite; secondary, inclusion-free augite.

2. Most Modified Metagabbro with Remnant Ophitic Texture: inclusion-free hypersthene and hornblende after olivine and augite; minor inclusion-free secondary labradorite; garnet extensively developed in rims around small residual areas of plagioclase. Minor augite, primary plagioclase remain.

D-3

The metagabbro with remnant ophitic texture goes, over a 20-foot span, through a transitional amphibolite containing poikiloblastic garnet, into the porphyroblastic garnet amphibolite of the ore zone.

3. Amphibolite with Poikiloblastic Garnet: (general grain size 0.2 to 5 mm). Poikiloblastic garnet anhedra (1 to 3 mm) with inclusions of mineral associates; secondary plagioclase anhedra; hornblende and hypersthene are intimately associated.

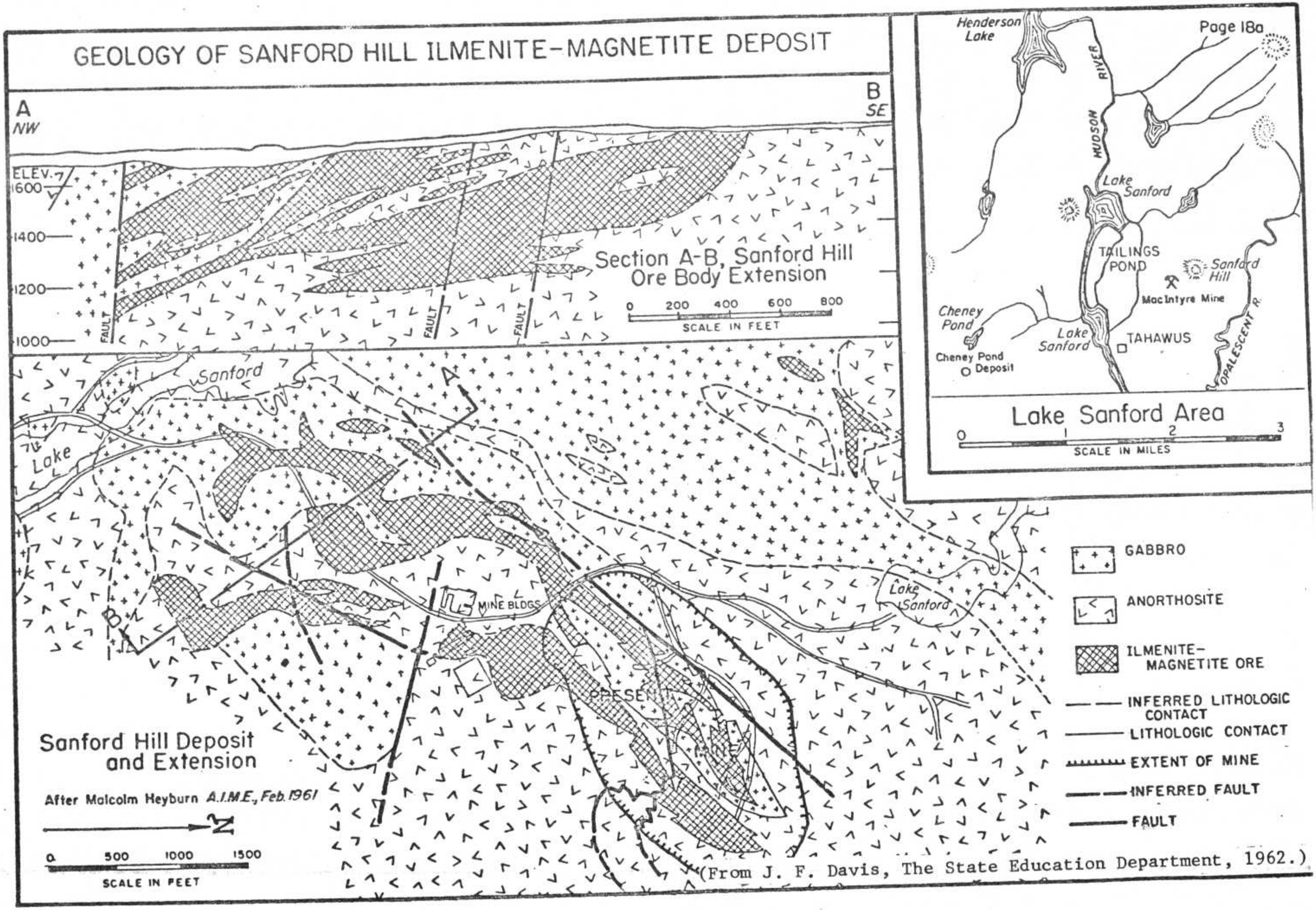
4. Porphyroblastic Garnet Amphibolite: giant subhedral garnet porphyroblasts, 1 to 30 cm and larger; narrow rims of plagioclase and outer sheaths of hornblende surround garnet crystals; matrix is labradorite (1 to 2 mm) and hornblende (2 to 5 mm); minor hypersthene.

The bulk composition of all varieties of the metagabbro is comparable to Buddington's average of 15 Adirondack metagabbros. The garnet tenor of the "dark ore zone" is 10 percent compared to 20 percent in other varieties of metagabbro. The garnet of all phases is pyrope-almandite ranging from 35 to 45 atomic percent Mg, 40 to 50 percent Fe^{+2} and 15 to 20 percent Ca. Hornblendite is present in portions of the "dark ore zone."

D. "Light Ore Zone": thin rock unit of variable mineralogy adjacent to charnockite; much more plagioclase than dark ore zone; plagioclase composition varies greatly; small aggregates of hypersthene and hornblende. In levels 3 and 4, inclusion-free anhedra and euhedra occur in mineable quantity.

Origin: The "dark ore zone" has definitely been produced during the metamorphism of the metagabbro. The nature of this metamorphism (regional or contact) is controversial and depends upon one's interpretation of the petrogenic relationships of anorthosite, metagabbro, and charnockite in the Adirondacks.

LEVIN, S. BENEDICT (1950) Genesis of Some Adirondack Garnet Deposits: Bull. Geol. Soc. Amer., V. 61, pp. 519-565.
BARTHOLOME, PAUL (1958) The Gore Mountain Garnet Deposit, New York - Structure and Petrography: Economic Geol., V. 55, No. 2.



(From J. F. Davis, The State Education Department, 1962.)

DESCRIPTION OF THE SANFORD HILL ORE BODY - MAC INTYRE MINE

I. Regional Geology: Two types of commercial magnetite deposits exist in the Adirondacks. Nontitaniferous magnetite ores are associated with leucogranitic gneisses and are present in the northeastern and northwestern Adirondacks (Lyon Mountain-Mineville-Port Henry, and Star Lake, respectively). Titaniferous magnetite deposits are associated with anorthosite and are situated along the east-central margin of the anorthosite massif and in the Lake Sanford area. The Sanford Hill ore deposit, north of Tahawus, and the Cheney Lake body, 1 mile west of Tahawus, are the best known occurrences.

II. Lithologic Descriptions:

A. Anorthosite: labradorite megacrysts (4 cm) in 1 to 4 mm matrix of labradorite; clinopyroxene and hornblende; mafic minerals less than 15 percent.

B. Gabbroic anorthosite: labradorite megacrysts in matrix of labradorite and clinopyroxene; mafic minerals constitute 15 to 35 percent of matrix.

C. Gabbro: (usage explained in origin discussion) The rock is composed of equigranular grains 1 to 4 mm; labradorite and clinopyroxene predominate; basaltic hornblende or hypersthene may be present; mafics range from 35 to 75 percent.

D. Ilmenite-magnetite ore: magnetite and ilmenite present as subhedral grains 1 to 2 mm; ilmenite often embays and veins magnetite grains; magnetite contains very minute irregular bodies of ilmenite and coarser ilmenite exsolution lamellae along (111) planes; labradorite, garnet, and pyroxene are gangue minerals.

III. Relationships of Lithologies: All of the lithologies in the Sanford Hill area have the same major mineral constituents. The principal contrasts are in the proportions in which the constituents are present. Gabbro-anorthosite contacts are gradational; gabbro-ore contacts are gradational; anorthosite-ore contacts are very sharp; several inches of pyroxene-garnet rock separate the two lithologies.

IV. Sanford Hill Ore Deposit: Two planar ore bodies are present, striking northeast and dipping northwest. The hanging wall ore body is situated within gabbro and has transitional contacts. The footwall ore body is located within anorthosite and has sharp contacts. The hanging wall ore body has a greater proportion of ilmenite to magnetite than the footwall ore body.

V. Origin: The designation of mafic varieties of the Adirondack anorthosite as "gabbro" is traditional in the literature, and the term is employed here. No remnant ophitic texture is present in any of the mafic varieties of the anorthosite. The origin of the gabbro and the associated anorthosite is controversial. Stephenson suggested the ore crystallized as a late-stage residuum of a gabbroic magma from which the anorthosite and then the gabbro had consolidated. Gillson has suggested the ores are epigenetic hydrothermal deposits.

GILLSON, J. L. (1956) Genesis of Titaniferous Magnetites and Associated Rocks of the Lake Sanford District, New York: Transactions AIME, pp. 296-302

HEYBURN, MALCOLM (1961) Geologic Mapping With the Aid of Magnetics, Tahawus Area, New York: Transactions AIME, Feb. 26, 12 p.

STEPHENSON, ROBERT C. (1945) Titaniferous Magnetite Deposits of the Lake Sanford Area, New York: N.Y. State Museum Bull. No. 340, pp. 1-95

27.3 This section of the Northway received the 1966-67 Most Scenic Highway Award.

30.9 Turn right at Exit 23 - Warrensburg.

31.2 Left to routes U.S. 9 and N.Y. 28.

31.5 Right (north) on U.S. 9 to N.Y. 28.

35.6 Left at fork on N.Y. 28.

39.8 On the right, an outcrop of a basalt sill in a granitic gneiss. On the left is the Hudson River.

The dominant rock type of this outcrop is a gneiss of granitic composition. The rock varies from pure black and white banding to a very high percentage of pink potassium feldspar.

At the north end of the outcrop is an excellent exposure of a basalt sill intruding the gneiss. At the contact, there are good examples of baking of the gneiss and chilling of the basalt to an almost glassy texture. There are tiny dinklets of basalt in the gneiss. Away from the contact, the gneiss assumes its normal texture and the basalt becomes more coarse grained.

40.5 On the left is an outcrop of marble.

The marble exposed in this outcrop is typical of the Adirondack marbles. The outcrop is cut by a number of small dikes showing chilled contacts and reaction with the surrounding marble. The marble contains graphite, vesuvianite and minor pyrite. In other localities (Brandt Lake) the graphite in the marble has been shown to have the right isotopic composition to be organic. The vesuvianite is a brown form of idocrase $[Ca_{10}Mg_2Al_4(Si_2O_7)_2(SiO_4)_5(OH)_4]$ commonly found as a contact metamorphic mineral in impure limestones.

46.3 Junction N.Y. 8, continue north on N.Y. 28.

51.8 Junction of N.Y. 28N, continue on N.Y. 28.

56.4 Turn left at Stetson's Store and Texaco onto Gore Mountain Road [note: the sparkles in the road are cleavages on the amphiboles used for road material.]

After crossing the R.R. tracks bear slightly left, continue to follow Gore Mountain Road.

61.2	Barton Mine [See the attached description of the mine and accompanying map from <u>Field Guide to the Central Portion of the Southern Adirondacks</u>, J. F. Davis, Educational Leaflet Series, No. 12 The State Education Department, State Museum and Science Service, Albany, 1962.]

* *

61.2	Return to N.Y. 28.
65.9	Turn right on N.Y. 28 to the village of North Creek.
70.5	Turn left onto N.Y. 28N at North Creek.
74.0	On the left is a prominant ridge that shows exfoliation. At the base of this ridge is a country rock quarry that shows the characteristic pink and green gneisses of the Adirondacks.
91.1	On the right is a plaque marking the approximate spot where Theodore Roosevelt became President of the United States.
92.3	Turn right onto road to Tahawn (sign marks the road) to National Lead Co. MacIntyre development.
93.4	Bear left at fork in road and continue toward Tahawn (Ignore the "Dead End Road" sign.).
93.9	Fork in road, bear left on paved road.
99.9	Fork in road, continue straight across bridge, turn sharp right. (Ignore threatening signs.) Waste piles are the country rock of anorthosite and gabbro.
101.1	Turn left into visitors overlook. [See the attached description of the mine and accompanying map from Field Guide to the Central Portion of the Southern Adirondacks, J. F. Davis, Educational Leaflet Series No. 12, The State Education Department, State Museum and Science Service, Albany, 1962.]

* *

101.1	Retrace the route away from the mine.
116.1	At the fork in the road, turn left (east) toward U.S. 9.
133.8	Enter Northway I 87 south.
140.7	Junction Northway I 87 and N.Y. 74, Schroon Lake Exit 27.

* *

Optional Side Trip
(mileage not included in the total)

6.5 miles east of the Northway I 87 on N.Y. 74. Park on the left at an abandoned motel just beyond the town of Paradox.

The mountain next to you is Skiff Mountain. The ridge itself is a complex refolded fold of Adirondack Gneisses and amphibolite. Included in the sequence is a bed of pure specular magnetite. In the recent past this body was mined by hand. The miners followed the band around the edge of the mountain. The country rock was removed from below the magnetite and then the ore was pulled down from the roof. The magnetite found here is very magnetic.

* *

191.2 Exit 15 Northway I 87, N.Y. 50, Saratoga Springs.